Implementing better practice Murray cod fishery management

Recreational Fishing Grants Program
Research Report

Your fishing licence fees at work

Arthur Rylah Institute for environmental research

Trelly's Tackle World Shepparton

Codger

FRDC

Victoria State Government

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Executive summary

This project aimed to improve our understanding and management of Murray cod (*Maccullochella peelii*) recreational fisheries, by extending baseline scientific information on Victorian fisheries and utilizing recreational anglers as citizen scientists to collect information that complements research programs supporting fisheries management.

This report combined results from scientific angling events and electrofishing surveys of the Loddon River undertaken under this RFL Project, "Implementing better practice Murray cod fishery management", and scientific angling events and electrofishing surveys on the Goulburn and Ovens rivers conducted as part of the larger basin-wide project, "Integrating fisher-derived and fishery-independent survey data to better understand and manage the Murray Cod fishery in the Murray-Darling Basin" (Project 2013/022).

Nine scientific angling events along with electro-fishing surveys following each event, were conducted on the Goulburn, Loddon and Ovens rivers, over three consecutive years between 2015 and 2018.

Anglers fished for a total of 1,861 hours, catching and tagging 143 Murray cod ranging in size from 20 to 100 cm. Most Murray cod were caught in the Ovens River (97), followed by the Goulburn River (38), while just five fish were angled from the Loddon River. Angler catch rates ranged from 0-0.77 fish/ angler hr.

Electro-fishing surveys caught 790 Murray cod ranging in size from 4.5 to 124.5 cm, with most fish being caught in the Ovens River, the Goulburn River and then the Loddon River. Electrofishing catch rate ranged from 0-1.67 fish/ min. Results suggested that the abundance of Murray cod in the Ovens and Goulburn rivers has increased, but there has been little change in the Loddon River compared to historic records.

The reasons why no Murray cod tagged by anglers were recaptured by anglers is not clear, though may be related the low number of fish tagged at any one site, and that fish caught, tagged and released by anglers may have learnt to avoid lures and been less catchable. Mortality following catch and release may also have been a factor. In contrast to angling, electrofishing recaptured 48 tagged Murray cod, seven of these were tagged by anglers.

Electrofishing tag-release-recapture data was used to estimate abundance of Murray cod in the Goulburn and Ovens rivers, which were 120 fish/ km (39.8 fish/ ha) and 171 fish/ km (66.0 fish/ ha), respectively. Insufficient Murray cod were tagged and recaptured to estimate abundance in the Loddon River.

This project sort to detect a change in the size structure of Murray cod and abundance of larger fish due to an introduction of new size limit regulations to the fishery by comparing historic data (Goulburn River: 2006-2011. Ovens River: 2008-2011) with current data. However, results were unclear and contradictory.

Anglers mainly fished with lures and to a lesser extent baits. The greatest proportion Murray cod (51%) and golden perch (39%) were caught on spinnerbaits, followed by hard-bodied bib lures (Murray cod 24%, golden perch 36%).

Cost benefit analyses indicated that electrofishing was substantially more cost-effective in capturing Murray cod (range $63-$2,500, mean $605 per fish caught), and caught a wider size range, than for angling (range $213 - $6,077, mean $1,928 fish).

The project had strong support from, and engagement with, anglers in research supporting Murray cod fishery management. Although angling was less cost effective at catching Murray cod than electrofishing, scientific angling events also provided:

- complementary fishery information (angler catch rates, size of fish caught and length-dependent vulnerability estimates), which will assist fishery management
- Broader social engagement with the recreational angling community through participation of anglers in events and social media outputs following events (by angers participating in events).

Recommendations

The project demonstrated that recreational anglers can undertake scientific activities, such as catch, measure, tag and release Murray cod, and provide information that will complement research programs supporting fisheries management objectives. Further involvement by anglers in supporting fisheries research and management may be achieved through participation in the VFAs Angler Diary Program and by using the *GoFishVic* App

Utilising anglers to catch, measure, tag and release Murray cod may be considered an option to improve information gathering on specific fisheries. For example, instigating an angler-based catch, tag and release program in Lake Eildon for Murray cod and golden perch will provide information on the growth, distribution and movement of these species in the lake, the size of the populations, social and economic value of the fisheries, as well as cost-effectively engaging anglers in fisheries research.

This project suggested it was too soon to detect a meaningful change in size structure of Murray cod and abundance of larger fish due to an introduction of new size limit regulations to the fishery. Further monitoring of the size structure of populations may be required within the next 5-10 years to detect a change.

Information collected from this project and the FRDC project will be combined with information from similar events undertaken in other states to better determine more robust estimates of the size and structure of Murray cod populations in Victoria and across the Murray Darling Basin.

The largest and smaller Murray cod caught by anglers. Ross Threlfall with a 100 cm Murray cod from the Ovens River in 2015 (Photo: Kelvin Williams). *Insert.* Ben Evens with a 20 cm cod caught in Ovens River in 2017 (Photo: Ray Miller).

Introduction

This project aimed to improve our understanding and management of the iconic Murray cod (*Maccullochella peelii*), one of the most popular freshwater recreational fish species in Australia. Improved management of Murray cod, such as changes to the Murray cod recreational fishery slot limit (Department of Environment and Primary Industries 2014) is expected to accelerate the rate of recovery of this threatened species, leading to higher abundance, better year class survival and better fishing, particularly for larger fish. Recent, once in a generation changes to size and bag limits for Murray cod have been well received by recreational fishers and, it is now important to collect detailed baseline information about current cod population status across representative rivers. This will enable us to measure how the fishery changes over the next decade as a result of recent slot limit changes.

In 2014, size regulations were changed from a 60-100 cm slot limit to a 55-75cm slot limit, which is expected to improve recreational fishing outcomes by increasing the long-term sustainably of the fishery by increasing the abundance of large fish (>1m) in the population and increasing the number of mid-size fish available for harvest (Allen *et al.* 2008, Department of Environment and Primary Industries 2014, Gwinn *et al.* 2015). This project originated from the Murray Cod Fisher Reference Group whom recommended a review of Murray cod regulations in five-years to evaluate the impact of these regulatory changes. Monitoring changes to Murray cod populations is important to ensure the fishery is sustainably managed. The Victorian Fisheries Authority (formerly Fisheries Victoria) also gave an in-principle commitment to key recreational fishery representative groups to monitor the effect of slot limits.

This project aimed to improve our understanding and management of Murray cod (*Maccullochella peelii*) recreational fisheries, by extending baseline scientific information on Victorian Murray cod populations and utilizing recreational anglers as citizen scientists to collect information that complements fishery independent research programs supporting fisheries management.

This report combined results from scientific angling events and electrofishing surveys of three Victorian rivers conducted under two projects:

- The Loddon River, as part of this RFL Project, “Implementing better practice Murray cod fishery management”
- The Goulburn and Ovens rivers, as part of a larger basin-wide project, “Integrating fisher-derived and fishery-independent survey data to better understand and manage the Murray Cod fishery in the Murray-Darling Basin” (Project 2013/022), funded by the Fisheries Research and Development Corporation (FRDC), the Victorian Government (VFA and DELWP) and interstate fisheries agencies. This project, which commenced in 2015, aimed to improve knowledge and management of Murray cod fisheries in the Murray-Darling Basin (MDB).

In the future the results from these projects will be combined with information from similar events undertaken in other states to better determine more robust estimates of the size and structure of Murray cod populations in Victoria and across the MDB, which will be reported as part of the FRDC project.

This RFL project and the FRDC project together will build knowledge and capacity within the recreational fishing sector, improve the quality of fisheries management debate and drive resource management and environmental advocacy among industry leaders. Importantly, these projects are helping to engage anglers in research supporting Murray cod fishery management.

Materials and methods

Rivers and sites fished

Scientific angling events and follow-up electro-fishing surveys were conducted in the Goulburn River (Mar.-Apr., 2015-2017) Loddon River (Feb.-Apr., 2016-2018), and Ovens River (Mar.-Apr., 2015-2017) (Figure 1, Table 1).

Sites fished in each river were selected on the basis that:

- They were navigable by boat
- There was an all-weather boat launching ramp nearby
- There were obvious landmarks that facilitated finding sites
- They were suitable for both angling and electro-fishing.

There were 12 sites along the Goulburn River (70 km reach), three sites in the Shepparton area, two sites between Shepparton and Toolamba, six sites in the Toolamba area, and one site near Murchison (Figure 2, Appendix I).

There were 10 sites along the Loddon River (65 km reach), two sites above Ferinhurst Weir, three sites above Serpentine Weir and five sites above Bridgewater (Figure 2, Appendix I).

There were 11 sites along the Ovens River (100 km reach), one downstream of the Murray Valley Highway, Eight sites in the Boorhaman North area, one in Wangaratta and one near Tarrawingee (Figure 2, Appendix I).

Each site was 1,000 m in length which was broken into a 500 m long “hot” zone plus a 250 m “grey” zone either end of the hot zone (Figure 3). Anglers were asked to concentrate fishing in the hot zone whereas electrofishing was confined to the hot zone. In each river there were more sites than scientific angling teams to allow for contingencies regarding unforeseen circumstances (e.g. anglers can’t access allocated site due to obstructions, etc.).

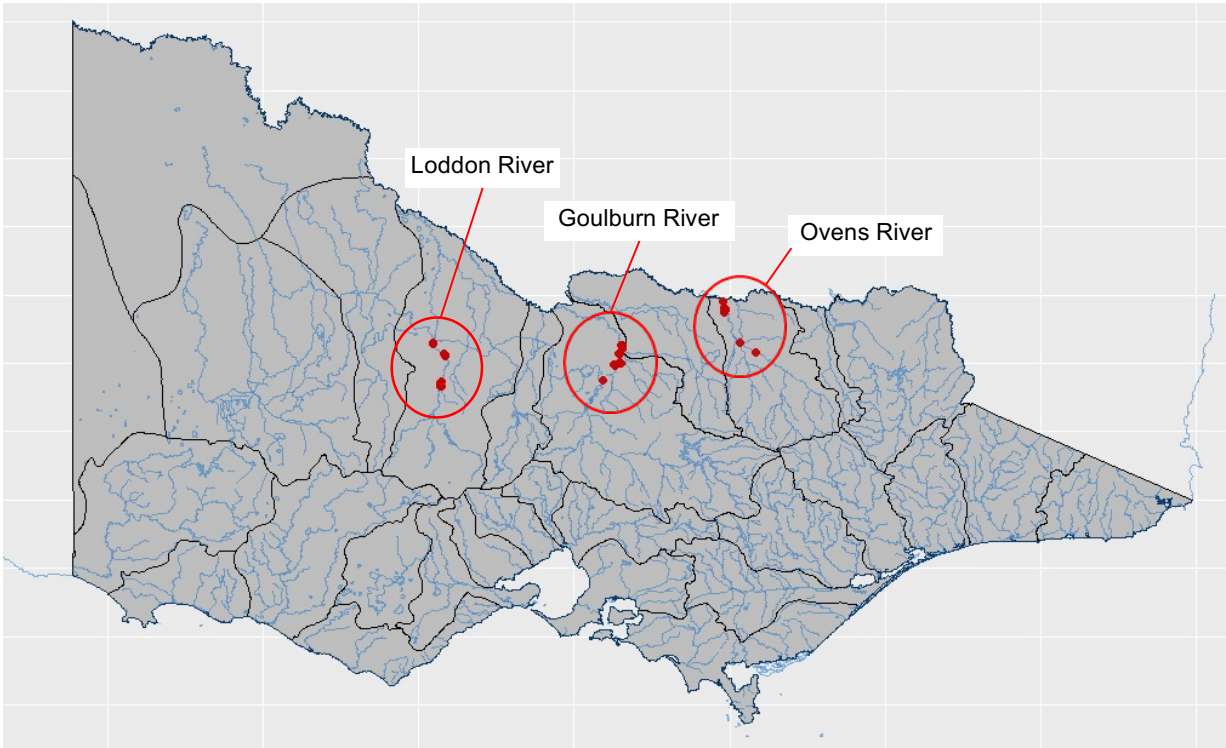


Figure 1. Rivers in which scientific angling events and follow-up electro-fishing surveys were undertaken between 2015 and 2018.

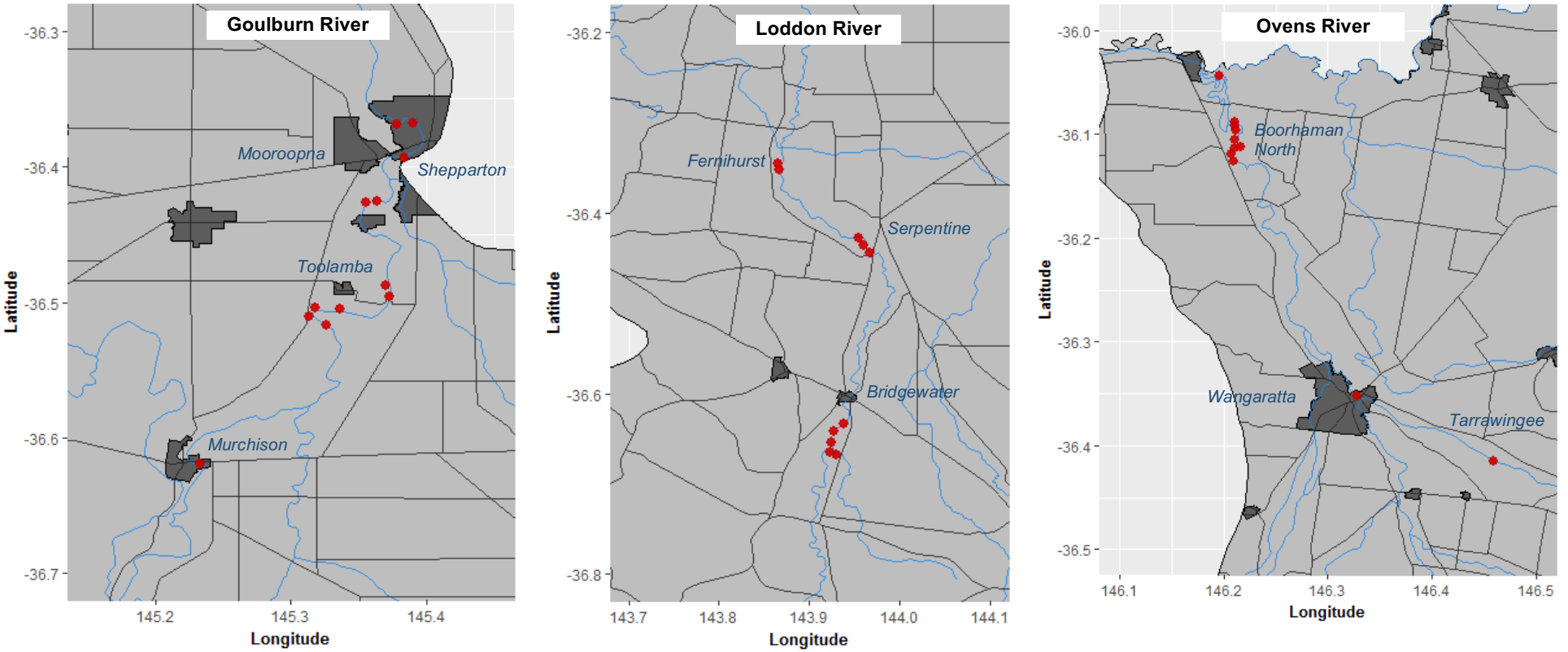


Figure 2. Sites fished during scientific angling events in the Goulburn River, Loddon River and Ovens Rivers.

Table 1. Dates when each river was angled and electro-fished.

Year	Fishing method	Goulburn R.	Loddon R.	Ovens R.
2015	Scientific angling	14-15 March		28-29 March
	Electrofishing	16 & 19 March		29-30 March & 1-2 April
2016	Scientific angling	19-20 March	13-14 February	5-6 March
	Electrofishing	21 & 24 March	15 & 18 February	7-8 & 10-11 March
2017	Scientific angling	22-23 April	4-5 March	25-26 March
	Electrofishing	24 & 27 April	6 & 9 March	27-28 & 30-31 March
2018	Scientific angling		21-22 April	
	Electrofishing		24 & 26 April	

Figure 3. Toolamba Boat Ramp Site C, Goulburn River showing location of "hot" fishing zone (red) and "grey" (yellow) fishing zone, and boat launching ramp.

Streamer tags

Fish tags are used to identify individuals and groups of individuals. Information from recaptured fish that have been tagged and released is used to understand fish stocks (size and distribution), fish growth, fish survival and fish movement.

In the current study, Type PST2S Polyethylene streamer tags (sequentially numbered, yellow colour, approximately 95 mm long with a 50 mm removable needle) (Hallprint, Hindmarsh Valley, S.A.) were used for tagging Murray cod (Appendix II). These tags were selected for the following reasons:

- Are temporary. A streamer tag evaluation trial indicated that tags implanted through the soft tissue between the dorsal spines was retained for at least 2 weeks. During surveys in the current study, anglers implanted 2 tags in each fish (to account for possible tag loss). All tagged Murray cod recaptured by electro-fishing in the following week had 2 tags present indicating that tag loss was negligible
- Are simple, straightforward and quick to apply. Streamer tags could be applied without sedating fish and did not require additional equipment to use. Participating anglers in the study indicated no problems with their use
- Cause minimal stress and injury to fish. Implanting streamer tags through the soft tissue between the dorsal spines was less invasive than using other types of fish tags, such as T-bar and anchor tags that are imbedded into the musculature.

Scientific angling

Prior to commencing fishing at each event, participating anglers were provided with:

- A presentation about the project, its objectives and expected outcomes, scientific angling methods to be used in the event, animal ethics requirements and volunteer safety instructions
- Training in tagging Murray cod with streamer tags (video and documentation) (Appendix II)
- A volunteer safety pack including emergency contact numbers, “Operating procedures for small water craft”, “General Boating/Scientific Angling”, “Safe Operating Instructions-Trailer”, “Safe Operating Instructions- Boats Small Aluminum & Inflatable” and use of life jackets (Appendix III)
- “National Code of Practice for Recreational & Sport Fishing” (http://recfishaustralia.org.au/national-code-of-practice-2010/)
- Current Victorian recreational fishing guide to rules and practices
- A pack of streamer tags for tagging Murray cod and a disposal container for streamer tag needles
- Directions to the fishing site and detailed map of site
- Scientific angler catch cards for recording fishing effect and fish captures (Appendix IV).

Participating anglers were required to:

- Participate in the training session outlining project objectives and methodology
- Understand the aims of project
- Understand the guidelines for tagging Murray cod
- Abide by the National Code of Practice for Recreational & Sport Fishing, which addresses four main areas of fishing responsibility; treating fish humanely, looking after our fisheries, protecting the environment and respecting the rights of others
- Have a valid Victorian Recreational Fishing Licence and will fish in accordance with the licence requirements.

Angling methodology

At each event, each site was fished by one scientific angling team only (one boat with 2-4 anglers on board), and sites were randomly allocated to teams.

Each team of anglers intensively fished the allocated site for at least 4 hours on Saturday and again on Sunday. The total length (TL) of all Murray cod caught were measured (nearest ½ cm), tagged for identification purposes and released. Murray cod were tagged with two streamer tags using the method described in Appendix II. If a tagged Murray cod was caught, anglers recorded the tag numbers and released the fish. Irrespective of whether Murray cod were caught, the time spent fishing and other fish species caught were recorded on catch cards (Appendix IV).

Tagged 47 cm cod caught by Marc Ainsworth in Goulburn River in 2015 (Photo: Marc Ainsworth).

Bailey Thomas releasing a 65.5 cm cod caught in the Loddon River in 2018 (Photo: Travis Dattolino).

Electrofishing surveys

In the week following each scientific angling event, an electro-fishing team surveyed six designated sites. Surveys were conducted in the hot zone of the same sites within each river in each year (Appendix I).

On the first day, each site was electro-fished (boat-mounted) using a standardized (Sustainable Rivers Audit - SRA) fish sampling method, which involved completing 12 random shots, each lasting 90 seconds (18 minutes per site) (Davies *et al.* 2008, Davies *et al.* 2010). All Murray cod that were caught were measured and those >6 cm tagged, and then released.

On the second day (3-4 days after the first day), each site of was electro-fished using a targeted method (15-28 minutes per site), which aimed to capture as many Murray cod as possible. All Murray cod that were caught were measured and those >6 cm tagged, and then released. If tagged Murray cod were caught, tag numbers were recorded, and the fish released.

Data management and analyses

All data from scientific angling events and electro-fishing surveys were entered into Microsoft Excel databases, which were transferred to fisheries modellers for detailed analyses along with similar data from other states, as part of the FRDC project (see Appendix V of reports to date).

For this report, all data from scientific angling events and electro-fishing surveys were summarized using descriptive summary statistics for presentation in tables and graphs.

Angling catch rate (catch per unit effort - CPUE) was calculated as number of Murray cod caught per hour fished per angler (fish/ angler-hr), and as number of hours required to angle a Murray cod (hr/fish).

Electrofishing CPUE was calculated as fish per minute (fish/min).

Significant differences in the length frequency distribution of Murray cod between rivers were identified using the Kruskal-Wallis Rank Sum Test (Ogle 2007b) (http://derekogle.com/aiffd2007/).

Population size estimation

A preliminary estimation of population size ($\hat{N}$) was undertaken for the Goulburn and Ovens rivers using tag-recapture data from electrofishing surveys only. The Loddon river was not analysed due to the small sample size. Angler data was also not analysed as no Murray cod tagged by anglers were recaptured by anglers. The R software Package “Rcapture” (Ogle 2007a, Baillargeon and Rivest 2014), which uses loglinear models, was used to estimate abundance from tag-recapture data. Populations were considered to be closed as fish were tagged on the first day and then re-surveyed 3 days later, assuming that there was there was no recruitment (birth or immigration) or losses (death or emigration) during the period, all fish had the same probability of being caught and that no tags were lost between sampling events (Gwinn *et al.* 2011, Brown 2012). Tag-recapture data for the six surveyed sites in each river (representing 3 km of river) were combined for each year for analysis. Site dimensions (length and area) were estimated from satellite imagery (https://www.google.com.au/earth/).

Effects of fishery slot limit regulation on length of Murray cod

In 2014, a new more restricted slot limit for the Murray cod recreational fishery was introduced (Department of Environment and Primary Industries 2014). The minimum legal size was reduced from 60 cm to 55 cm and the maximum was reduced from 100 cm to 75 cm. To seek evidence of any potential effects of this regulation change on the size distribution of Murray cod and catch rate of Murray cod >75cm, fish caught from the Goulburn River and Ovens River by electro-fishing methods during the present study (2015-2017) were compared with fish caught from these rivers during electro-fishing surveys conducted in the same areas as the present study before the regulation was introduced. These were 463 Murray cod caught in the Goulburn River over five years between 2006 and 2011, and 398 Murray cod caught in the Ovens river over four years between 2008 and 2011. Loddon River data were not evaluated due to small sample sizes in both current and historic records.

Cost benefit analysis

To estimate the cost of capturing Murray cod by both angling and electrofishing, costs associated with organising and running scientific angling events were recorded. These costs included:

- Planning, logistics and oversite of events by FVA staff

- Accommodation. Two nights per event (each angling team shared a room or cabin)
- Meals. Six meals per event (2 dinners, 2 breakfasts and 2 lunches)
- Re-imbursement of travel costs (fuel) to and from events. This was made available to all participating anglers, but only a small number sort re-imbursement
- Incidentals (fish boxes, landing nets, containers for fish tags, plastic folders for catch cards and other documentation)

Cost of electrofishing surveys was nominally $10,000 per event.

Travis Dattolino releasing a 54 cm cod from the Loddon River in 2018 (Photo: Franz Graser).

Kaye Goggin tagging a cod caught in the Goulburn River in 2016 (Photo: Anita Wilson).

Anita Wilson with a 39 cm cod from the Ovens River 2017 (Photo: Deanne Brassil).

Results and discussion

A total of nine scientific angling events were conducted, three each on the Goulburn (2015-2017), Loddon (2016-2018) and Ovens rivers (2015-2017) (Table 1, Appendix I). A summary of results from these events are provided in Appendix V.

A total of 154 anglers took part in the events, representing 68 individuals (8 females and 60 males), of which half participated in more than one event and one that took part in all nine events. Together, anglers fished for a total of 1,861 hours during the events. Hours fished by anglers ranged from 2.5-14.5 hr/day per angler (mean 6.2 hrs/day per angler), and typically more hours were fished on Saturday (mean 7.3 hr per angler) than Sunday (mean 5.1 hr angler).

The combined time fished by electro-fishers was 35.6 hours

Number of fish caught

A total of 252 fish were caught by anglers, most of which were Murray cod (143) followed by golden perch (83) and then trout cod (19) (Table 2). Most Murray cod were caught in the Ovens River (97), followed the Goulburn River (38), while just five fish were angled from the Loddon River. Golden perch were caught in all rivers, trout cod in the Goulburn and Ovens rivers, and silver perch in the Goulburn River only.

Electro-fishing surveys caught 790 Murray cod ranging in size from 4.5-124.5 cm (Table 3).

Murray cod captures across sites within rivers

Angled Murray cod were caught at all sites in the Goulburn River, except for the most downstream site, Shepparton-C, and most angled Murray cod came from sites in the Toolamba area (Figure 4). Electrofishing surveys caught more Murray cod in the upstream sites, greater than fivefold that of Murray cod caught at the downstream site of Shepparton-B (Figure 4).

All angled Murray cod from the Loddon River were caught at the downstream sites of Serpentine and Fernihurst whereas no Murray cod were caught in sites above Bridgewater (Figure 5). However, electro-fishing surveys caught Murray cod above Bridgwater as well as at two Serpentine sites and one Fernihurst site (Figure 5).

Murray cod were caught by scientific anglers at all sites in the Ovens River, although generally lower numbers were caught at the upstream sites of Tarrawingee and Wangaratta and the lowest downstream site of Parolas (Figure 6). In contrast, the number of Murray cod caught during electrofishing surveys increased from downstream sites to upstream sites (Figure 6), indicating that sampling may be influenced by water quality and/ or depth (Gwinn *et al.* 2016).

Table 2. Number and size of fish caught by scientific anglers in each river.

	Number caught (size range in cm)			
Species	**Goulburn R.**	**Loddon R.**	**Ovens R.**	**TOTAL**
Murray cod *(Maccullochella peelii)*	38 (25-83)	8 (42-65.5)	97 (20-100)	143 (20-100)
Trout cod (*Maccullochella macquariensis*)	17 (14-39)		2 (52-62.5)	19 (14-62.5)
Golden perch (*Macquaria ambigua*)	11 (38-45)	42 (22-52)	30 (38-57)	83 (22-57)
Silver perch (*Bidyanus bidyanus*)	5 (no data)			5 (no data)
Redfin perch (*Perca fluviatilis*)		1 (25)		1 (25)
Common carp (*Cyprinus carpio*)	1 (no data)			1 (no data)
TOTAL	**72**	**51**	**129**	**252**

Table 3. Number and size of Murray cod caught during electrofishing surveys of each river.

	Number caught (size range in cm)			
Species	**Goulburn R.**	**Loddon R.**	**Ovens R.**	**TOTAL**
Murray cod *(Maccullochella peelii)*	299 (4.5-124.5)	34 (8.4-91)	457 (6.5-101)	790 (4.5-124.5)

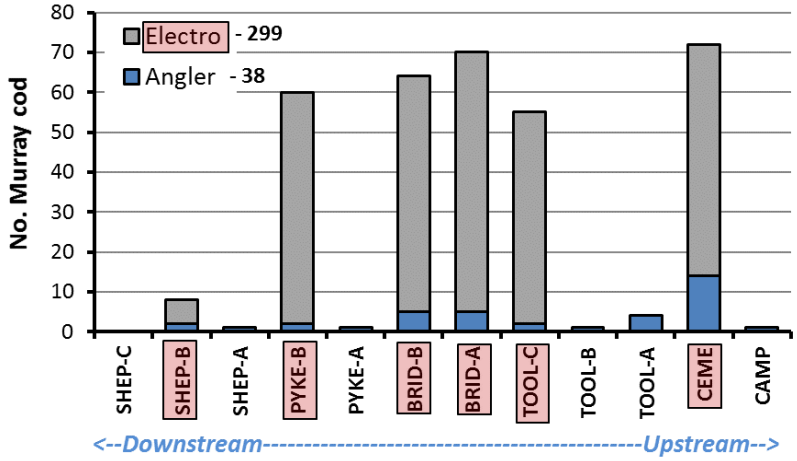


Figure 4. Number of Murray cod caught in the Goulburn River by angling and electro-fishing between 2015 and 2017.

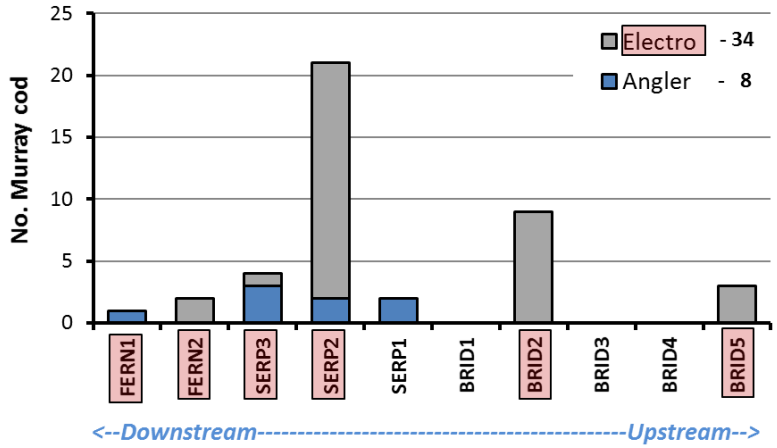


Figure 5. Number of Murray cod caught in the Loddon River by angling and electro-fishing between 2016 and 2018.

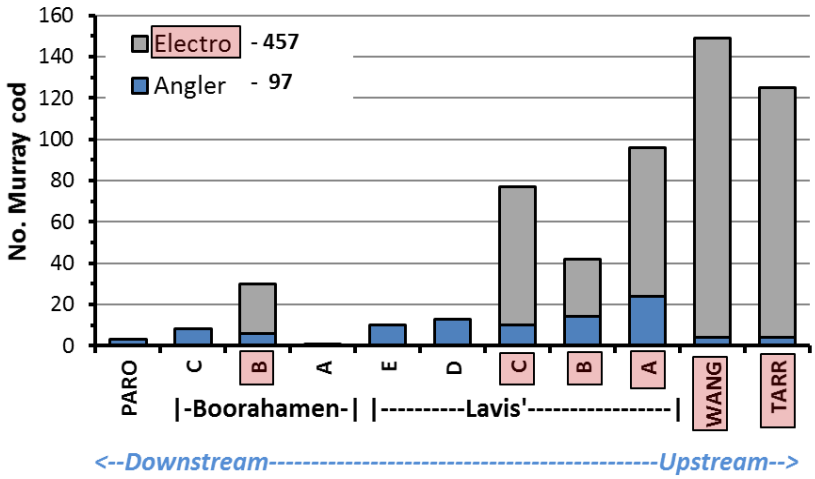


Figure 6. Number of Murray cod caught in the Ovens River by angling and electro-fishing between 2015 and 2017.

Catch rate

Angler catch rate

This study has shown that angler catch rates vary between 'river' and 'year', and 'day' fished over the weekend of events (Figure 7). Angler catch rate ranged from 0-0.77 fish/ angler-hr across all sites, rivers and years. Angling catch rate was highest for the Ovens River (mean 0.15 fish/ angler hr ± 0.02 s.e), which was more than double that of the Goulburn River (mean 0.06 fish/ angler-hr ± 0.01 s.e.) which, in turn, was three times that of the Loddon River (mean 0.02 fish/ angler-hr ± 0.01 s.e.) (Figure 7). In other boat-based angling surveys, for comparison, Brown (2010) estimated boat-based Murray cod catch rates of 0.123 fish/ angler-hr in the Murray River and 0.068 fish/ angler-hr in Victorian tributaries during surveys conducted between 2006 and 2008, whereas Forbes *et al.* ,(2015) recorded a rate of 0.228 fish/ angler-hr for the Murrumbidgee River (NSW) (2012-2013).

Differences were observed in angler catch rate between the first day of fishing (Saturday) and the second day of fishing (Sunday). In all years catch rate in the Ovens River was higher on Saturday (mean 0.19 fish/ angler hr) than Sunday (mean 0.10 fish/ angler hr), whereas in the Goulburn River, catch rate was higher on the Sunday for two of the three years (Saturday mean = 0.05 fish/ angler hr, Sunday mean 0.07 fish/ angler hr) (Figure 7).

There was no consistent trend in angler catch rate across years within each river. Angler catch rate increased over time in the Goulburn River and Loddon River, but was greatest in the middle year of the study for the Ovens River (Figure 7, Table 4).

The number of hours required to catch a Murray cod ranged from 5 hr/fish (Ovens River - 2016) to 91 hr/fish (Loddon River – 2016) (Figure 8).

Information provided by anglers on the scientific angler catch cards (Appendix IV) was used to estimate angler catch rates and size of angled fish. However, despite provision of training at each event and re-enforcing the need to fill in catch cards, even if no Murray cod were caught, there was always one or two teams on each day that did not complete cards.

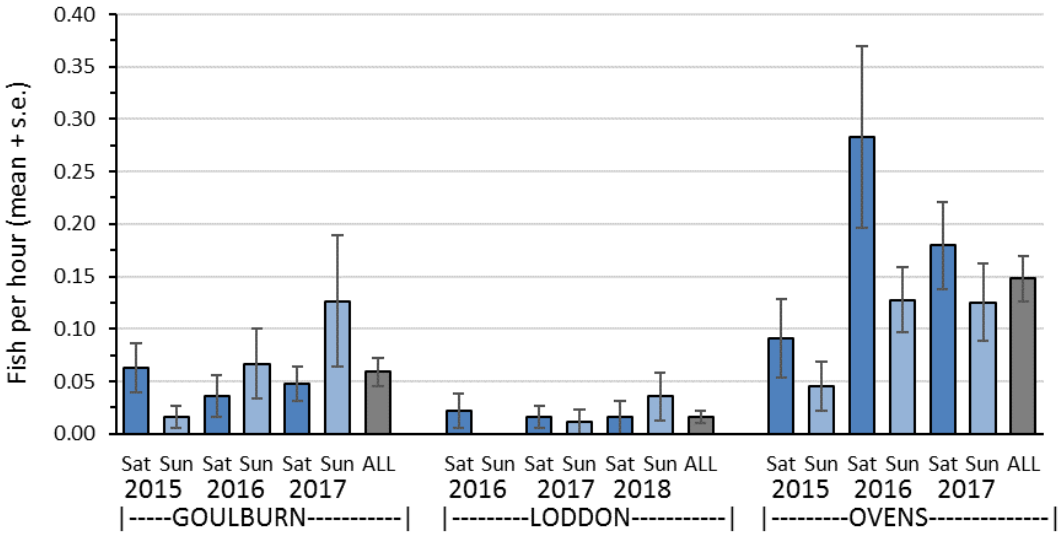


Figure 7. Angling catch per unit effort (fish/hr) for Murray cod caught in the Loddon, Goulburn and Ovens rivers.

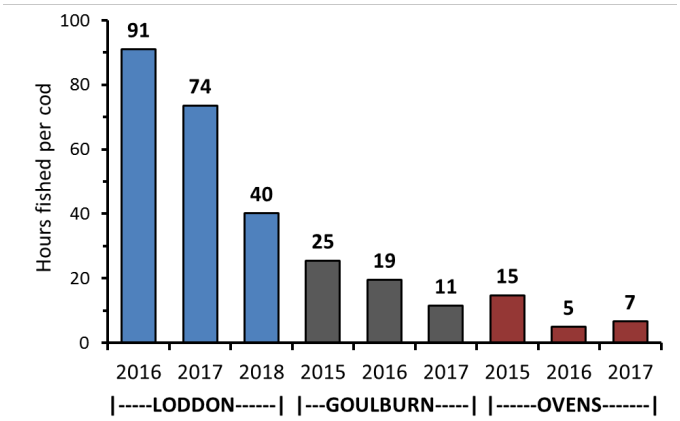


Figure 8. Mean number of hours required to catch a Murray cod by angling in the Loddon, Goulburn and Ovens rivers.

Electrofishing catch rate

Electrofishing catch per unit effort (CPUE) ranged from 0-1.67 fish/ min across all sites, rivers and years. As with angling CPUE, electrofishing CPUE was highest for the Ovens River (mean 0.65 fish/min ± 0.07 s.e), which was moderately higher than for the Goulburn River (mean 0.42 fish/min ± 0.04 s.e.), both of which were substantially higher than for the Loddon River (mean 0.05 fish/ min ± 0.02 s.e.) (Figure 9). There was no apparent trend in electrofishing CPUE across years within each river. CPUE was highest in the Goulburn and Loddon river in 2016, but was similar across all years in the Ovens River (Figure 9).

In comparison to historic electrofishing survey records, the abundance of Murray cod in the Ovens and Goulburn rivers has increased, but there has been little change in the Loddon River (see Appendix VI). The current study supports the view that the abundance of Murray cod in the Goulburn has increased in recent decades (Koster *et al.* 2004, Crook and Koster 2006, Koster *et al.* 2012). Electrofishing CPUE in the Ovens during the present study was 3-fold higher than historic records (1998 and 2011) (Appendix VI). Electrofishing CPUE in the Loddon River has not exceeded 0.12 fish/min over the last two decades (Appendix VI). Substantial stocking with hatchery-produced fingerlings does not appear to have enhanced the Murray cod fishery in the Loddon River. From 2007/08 to 2015/16, 20,000-70,000 Murray cod fingerlings were stocked annually into the Bridgwater area (359,500 fish over 9 seasons). An evaluation of fish stockings conducted in 2014 suggested that stocking did not contribute to wild stocks in the Loddon River (Ingram *et al.* 2015).

Differences observed between SRA CPUE and targeted CPUE within each year and river were variable, but in most cases the SRA CPUE was higher, the exceptions being the Goulburn River in 2016 and the Loddon River in 2016 (Figure 9).

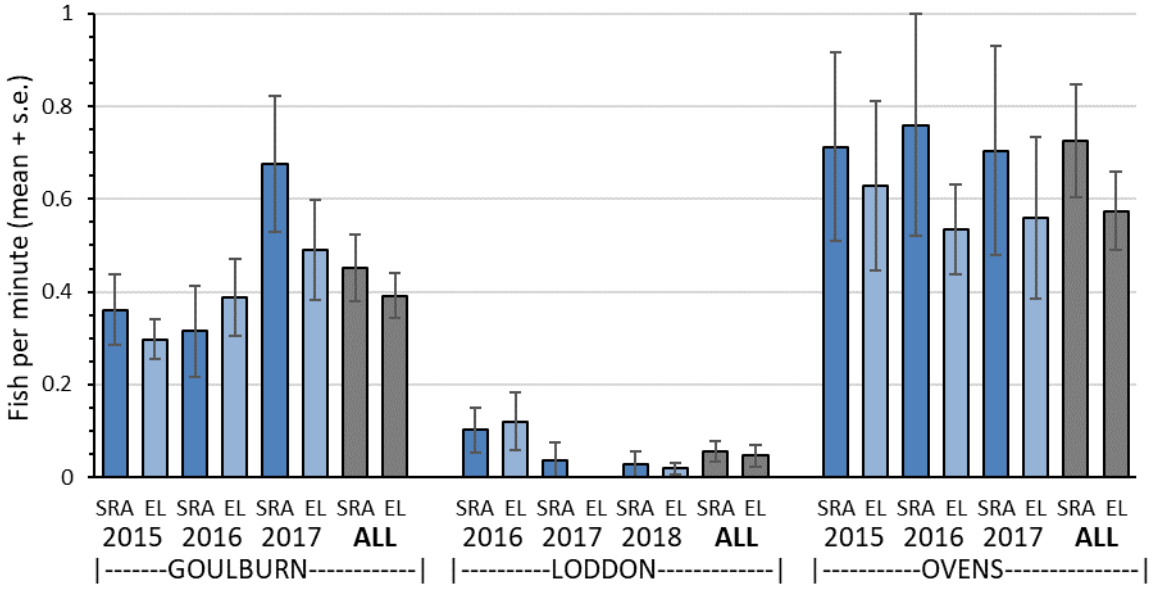


Figure 9. Electro-fishing catch per unit effort (fish/hr) for Murray cod caught using either the Sustainable Rivers Audit (SRA) sampling method or targeted electrofishing (EL) in the Loddon, Goulburn and Ovens rivers.

Population size estimation from tag-recapture data

A summary of the number of Murray cod caught and tagged by anglers and electro-fishers, and the number of these fish that were recaptured, is presented in Table 4. Anglers captured and tagged 143 Murray cod, but none of these were recaptured by anglers. The reason why anglers did not recapture tagged fish are not clear, though it may simply be due to the low number of fish tagged on the Saturday at any one site, which ranged from 1 to 9 fish (average 2 fish). Fish that had been caught, tagged and released on the Saturday may have been less catchable on the Sunday. A study on rainbow trout (*Oncorhynchus mykiss*) following catch-and-release found that angler catch rates quickly decreased, suggesting that fish learnt to avoid hooks (Askey *et al.* 2006). Mortality following catch and release may also have been a factor. Douglas *et al.* (2010) reported a survival rate of 98% in Murray cod 5 days after being hooked and released, whereas Hall *et al.* (2012) observed no mortalities in Murray cod 4 days after hooking in Winter and spring, but 15% died after delayed release in summer.

In contrast to angling, electrofishing surveys caught and tagged 349 on the first day of surveys in total, and 48 tagged Murray cod were recaptured during electro-fishing surveys, seven of these were tagged by anglers (Table 4).

Abundance estimates were calculated from electrofishing survey data for the Goulburn and Ovens rivers. Modelling suggested there were 120 fish/ km (lower 95% CL = 83, upper 95% CL = 200) in the Goulburn River, whereas there were 171 fish/ km (lower 95% CL = 132, upper 95% CL = 236) in the Ovens River. Based on average width at survey sites there were 39.8 fish/ ha and 66.0 fish/ ha Murray cod/ ha in the Goulburn River and Ovens River, respectively. These results were higher than abundance estimates calculated using a multiple census mark-recapture method for Murray cod electro-fished from the Goulburn and Ovens rivers between 2009 and 2010. Mean values ranged from 17-18 fish/ ha and 7-50 fish/ ha for the Goulburn River and Ovens River, respectively (Brown 2012) (35-78 fish/ km, Gwinn *et al.* 2011). Insufficient Murray cod were tagged and recaptured to estimate abundance in the Loddon River.

Justin Rees with a 58 cm cod from the Loddon River 2016 (Photo: Paul Thomas).

Paul Thomas with a tagged 63 cm cod from the Goulburn River in 2017 (Photo: Bailey Thomas).

Table 4. Number of fish tagged by anglers and electro-fisheries (SRA survey day), and number of tagged fish that were recaptured.

Event	Scientific angling			Electro-fishing survey						
	No. anglers	No. cod caught and tagged	No. tagged cod recaptured by anglers	No. cod caught on day one		No. of cod caught on day two			Percentage of recaptures by electrofishing (%)	
				Caught	Tagged	Total caught	Tagged by anglers	Tagged by electro-fishers	Fish tagged by anglers	Fish tagged by electro-fishers
Goulburn R. (2105)	21	10	0	78	25	39	1	4	10	16
Goulburn R. (2106)	18	12	0	87	30	50	3	4	25	13
Goulburn R. (2107)	19	16	0	134	70	61	0	3	0	4
Goulburn Total	**58**	**38**	**0**	**299**	**125**	**150**	**4**	**11**	**11**	**9**
Loddon R. (2016)	16	2	0	25	11	14	0	2	0	18
Loddon R. (2017)	15	3	0	4	1	1	0	0	0	0
Loddon R. (2018)	14	3	0	5	3	0	0	0	0	0
Loddon Total	**45**	**8**	**0**	**34**	**15**	**15**	**0**	**0**	**0**	**13**
Ovens R. (2015)	15	15	0	159	64	82	1	13	7	20
Ovens R. (2016)	17	45	0	153	72	71	1	5	2	7
Ovens R. (2017)	19	37	0	145	73	71	1	10	3	14
Ovens Total	**51**	**97**	**0**	**457**	**209**	**224**	**3**	**28**	**3**	**13**
TOTAL	**154**	**143**	**0**	**790**	**349**	**389**	**7**	**41**	**5**	**12**

Murray cod length-frequency distribution

Anglers caught and measured 143 Murray cod while electrofishing caught and measured 790 fish. Electro-fishing caught a broader size range of fish compared to angling (Figure 10), which reflects the selectivity of gear used; anglers fished mainly with lurers that targeted larger fish. Murray cod caught by anglers ranged in size from 20-100 cm in length, (80% of were between 36 and 65 cm), with both the smallest and largest fish being caught in the Ovens River.

In contrast to angling, Murray cod caught by electro-fishing ranged from 4.5-124.5 cm in length (80% were between 15 and 54 cm), with the smallest and largest both being caught in the Goulburn River.

The length frequency distributions of Murray cod were significantly different between rivers (Kruskal-Wallis chi-squared = 32.692, P <0.0001) (Figure 11). Murray cod caught by electrofishing were on average largest in the Loddon River (mean 46.4 cm), followed by the Ovens River (mean 34.0 cm) and then the Goulburn river (mean 31.2 cm) (Figure 11).

Gwinn et al (in prep.) used angler catch data from the present study, along with other data collected from the FRDC Project (Project 2013/022), to develop a novel method for estimating the length-dependent vulnerability of fish to capture by angling.

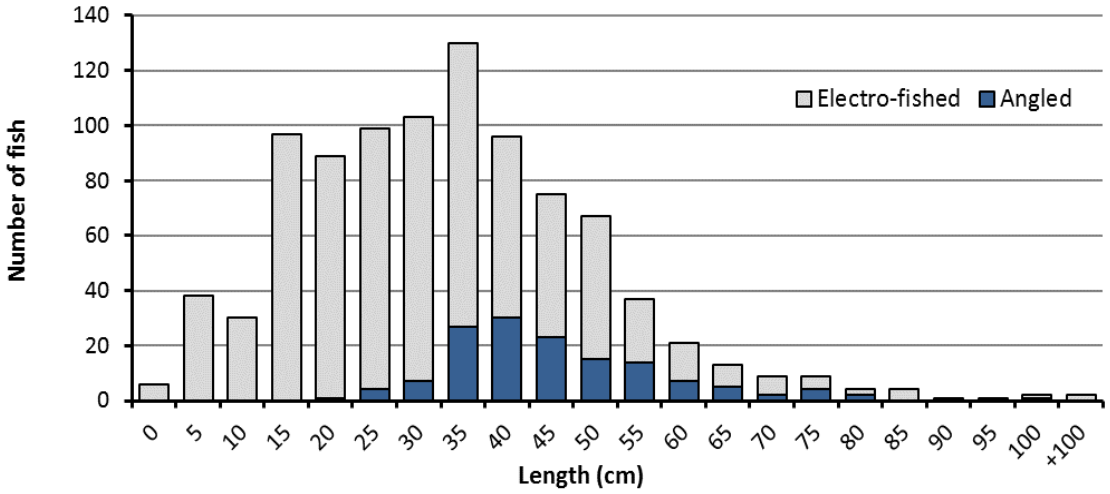


Figure 10. Length frequency distribution of all angled and electro-fished Murray cod from the current study.

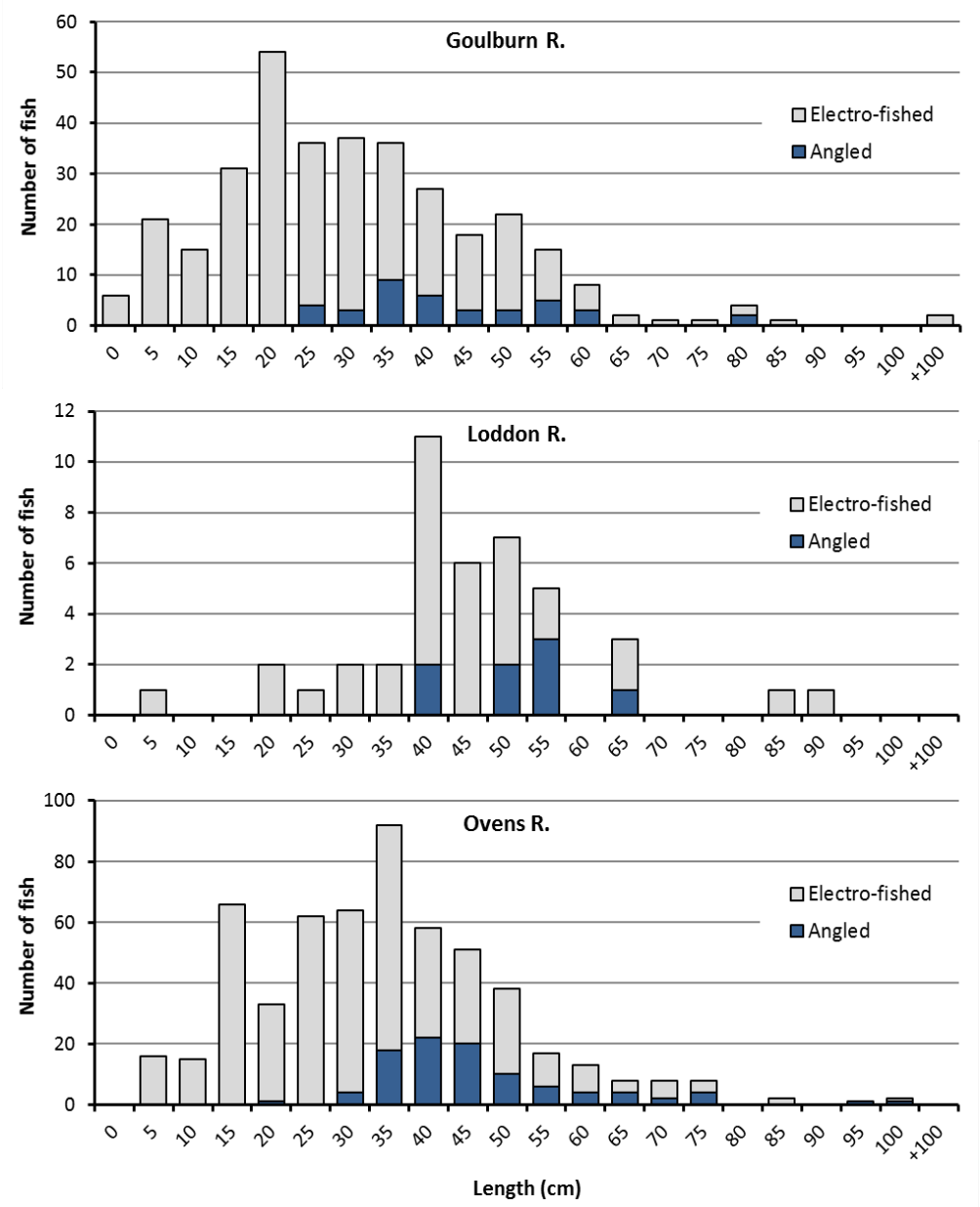


Figure 11. Length frequency distribution of Murray cod angled and electro-fished from the Goulburn River (2015-2017) and Loddon River (2016-2018) and Ovens River (2015-2017).

One of the larger cod (95 cm) caught in the Ovens River by Lubin Pfeiffer in 2015 (photo Shane Atze).

Effects of fishery slot limit regulation on length of Murray cod

The slot limit for Murray cod introduced in 2014 aimed to increase the long-term sustainably of the fishery, increase the abundance of large fish (>1m) in the population and increase the number of mid-size fish available for harvest (Allen *et al.* 2008, Department of Environment and Primary Industries 2014, Gwinn *et al.* 2015). However, results from the current evaluation were unclear and contradictory, which suggest that it may be too soon to detect a meaningful change in the size structure of Murray cod populations and abundance of larger fish due to changes to the slot limit. In the Goulburn River, both the catch rate of Murray cod over 75 cm and the percent of Murray cod over 75 cm were substantially greater in the current study compared to historic data in electro-fishing surveys between 2006 and 2011 no Murray cod over 75 cm were caught, In contrast, in the Ovens river both the catch rate of Murray cod over 75 cm and the percent of Murray cod over 75 cm were slightly lower in the current study compared to history data (Table 5). The length distribution Murray cod caught historically compared with that from the current study is presented in Figure 12.

Table 5. Electrofishing catch rate and percentage of catch for Murray cod >75 cm caught historically in the Goulburn River (2006-2011) and Ovens River (2008-2011), and caught in the current study.

Species	Historic		Current study	
	Catch rate	Percent of catch (%)	Catch rate	Percent of catch (%)
Goulburn River	2 fish in 217 hours (0.009 fish/hour)	0.43	6 fish in 12 hours (0.50 fish/hour)	2.37
Ovens River	9 fish in 14 hours (0.64 fish/hour)	2.26	7 fish in 12 hours (0.58 fish/hour)	2.17

These preliminary results must be viewed with caution because the available data have limited ability to detect this effect at this time for two primary reasons. Firstly, an increase in larger cod will occur as younger cohorts grow into this larger length range. A modelling evaluation that accounted for this biological lag suggested that a noticeable increase in the abundance of large (> 1 m) fish may take five to 10 years (Department of Environment and Primary Industries 2014). In the current study, four fish > 1 m were caught (one by anglers). Secondly, the influence of other variables on changes in the Murray cod length composition cannot be discounted. For example, a recent increase in larger Murray cod could also occur as a result of increasing trend towards catch and release by Murray cod anglers. Detecting the effects of the introduction of a fishery slot limit to the Murray cod recreational fishery may be masked by an increasing trend towards catch and release by Murray cod anglers. A nationwide recreational fishing survey conducted in early 2000s indicated that 77.6% of Murray cod caught by anglers were released, whereas higher total release rates were reported in more recent angler surveys; 63-100% in the Murray River and several Victorian rivers between 2006 and 2008 (Brown 2010), and 95% in the Murrumbidgee River in 2012-2013 (Forbes *et al.* 2015). However, release rates are affected by legal size limits. Brown (2011) indicated that most of the Murray cod caught in the Goulburn River were smaller than the legal minimum size (LMS) at that time (50 cm), but anglers also released large fish. The voluntary release rate of Murray cod over the LMS caught in the Goulburn River increased from 20% in 2006/07 to 50% in 2008/09 (Brown 2011). A more comprehensive evaluation will likely be needed in the future to detect the potential effects of the new harvest slot regulations.

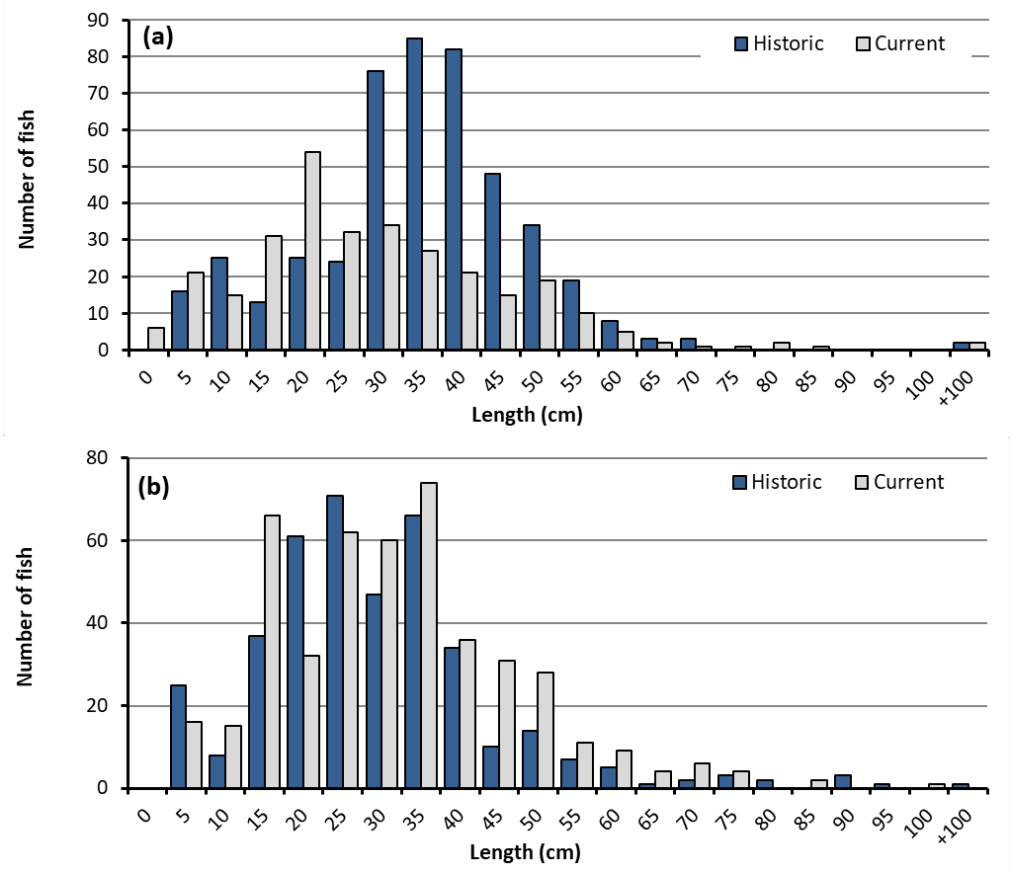


Figure 12. Historic and current length frequency distribution of Murray cod electro-fished from (a) the Goulburn River (Historic 2006-201, Current 2015-2017) and (b) the Ovens River (Historic 2008-2011, Current 2015-2017).

Bait and bite window

Anglers mainly fished with lures (e.g. spinnerbaits, bib lures, lipless crankbaits and surface lures) and to a lesser extent baits (bardie grubs, worms and yabbies). Most Murray cod (51%) and golden perch (39%) were caught on spinnerbaits, followed by hard-bodied bib lures (Murray cod 24%, golden perch 36%) (Figure 13). These results, however, may reflect angler preference rather than the effectiveness of a particular type of lure in catching fish. Yet again, the preferential use of certain lures by anglers may also reflect their experiences regarding which lures are more effective. Other factors affecting lure preference may also include frequency of snagging and cost of replacement (as much as $35 per lure).

Apart from lure type, size, colour, pattern and swimming action, lure retrieval style, angler skill and environmental condition (e.g. water clarity and light intensity) may also influence effectiveness. For example, northern pike (*Esox Lucius*) are more readily captured on soft plastic shad than lures (spoon) (Arlinghaus *et al.* 2017) while bright coloured soft plastic lures tended to capture larger largemouth bass (*Micropterus salmoides*) than darker or more natural coloured lures (Moraga *et al.* 2015). Unfortunately, there have been no detailed studies on the effectiveness of different lure types on catching Murray cod. However, these results may reflect both the popularity and effectives of spinnerbaits and hard-bodied lures for catching Murray cod and golden perch over other lure types, such as soft plastic and swim baits.

Most Murray cod were caught between 8:00 hr and 12:00 hr, which was also when the hours fished was highest (Figure 14a) The hours fished per Murray cod caught were lowest before 7:00 hr and after 19:00 hr (Figure 14b), but this times had the lowest hours fished and so may not be truly representative of the catch rate of Murray cod at this time of day. No fishing occurred before 5:30 hr and after 21:00 hr and so catch rate of fish during night-time cannot be elucidated.

As with Murray cod, most golden perch were more-or-less caught when fishing hours were greatest (between 8:00 hr and 12:00 hr), although at sometimes catch was high (e.g 14:00 – 15:00 hr) and low (e.g. 10:00 – 11:00 hr) (Figure 14c). The hours fished per golden perch caught was lowest occurred in the late afternoon (19:00 - 20:00 hr).

Catch rates of fish by anglers can be affected by more than the type of lure used and time of day as described above. For example, catch rate of pike by anglers is significantly affected by temperature, wind speed and moon phase (Kuparinen *et al.* 2010).

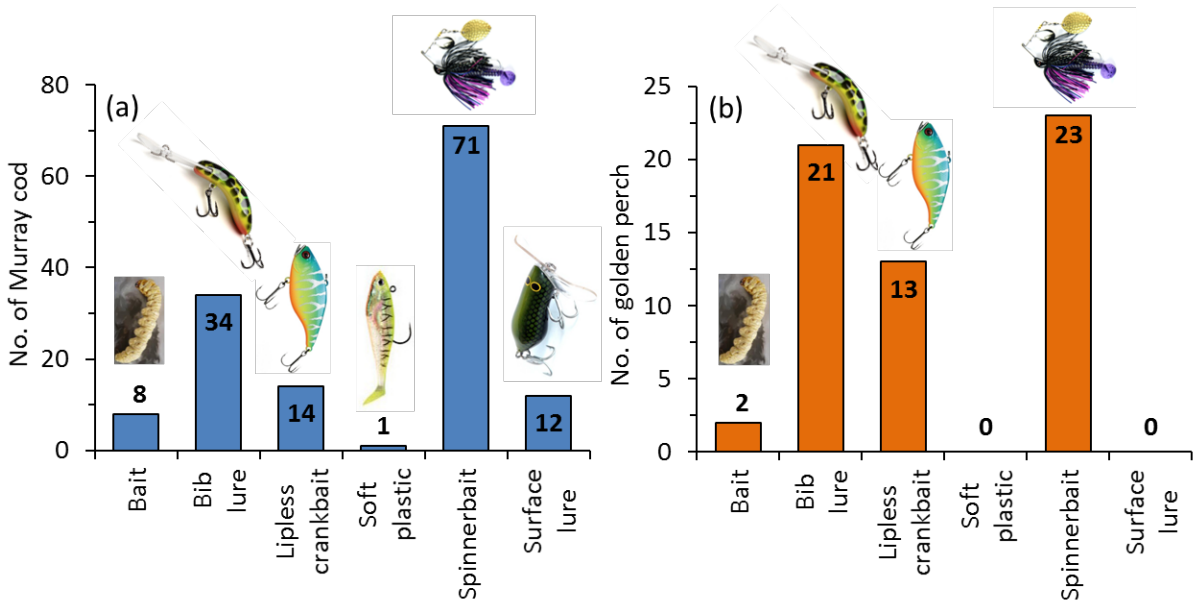


Figure 13. Number of Murray cod (a) and golden perch (b) caught on different baits and lures.

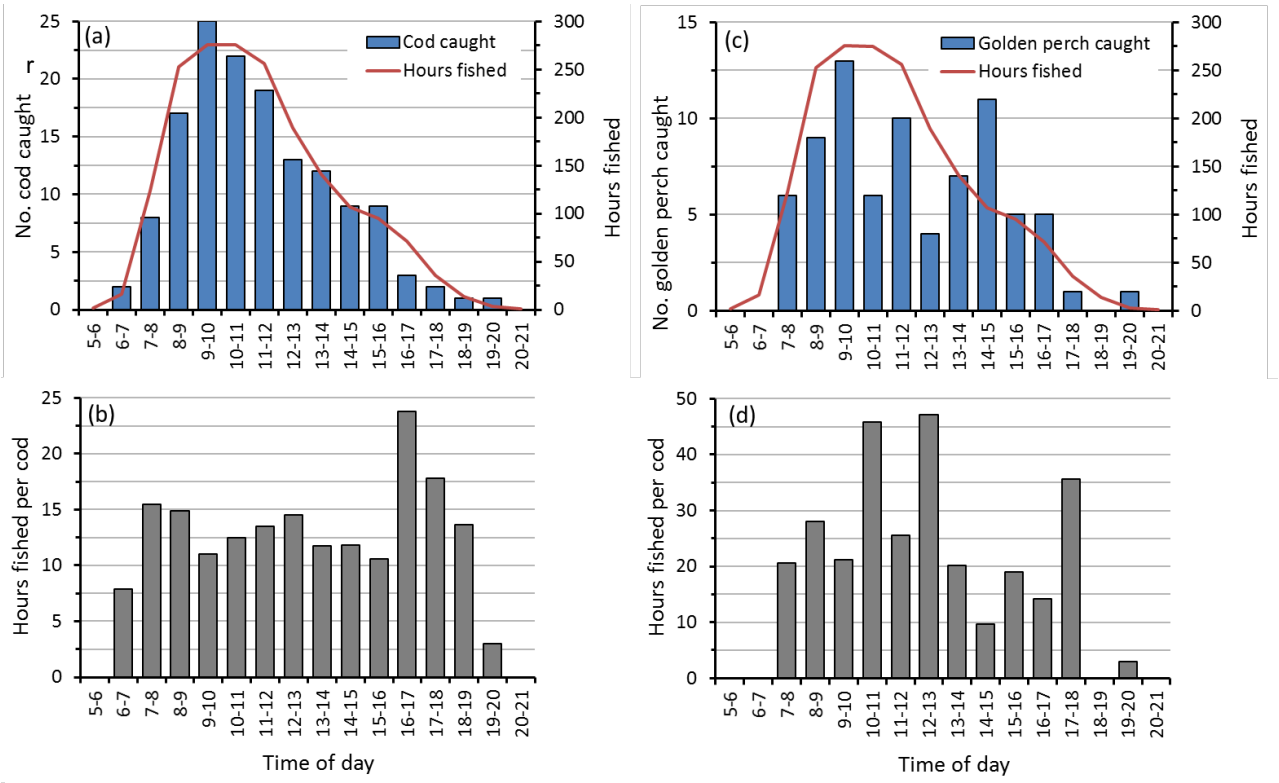


Figure 14. Accumulated hours fished per hour of day, number of fish caught each hour of the day and hours per fish for each hour of day for Murray cod (a and b) and golden perch (c and d).

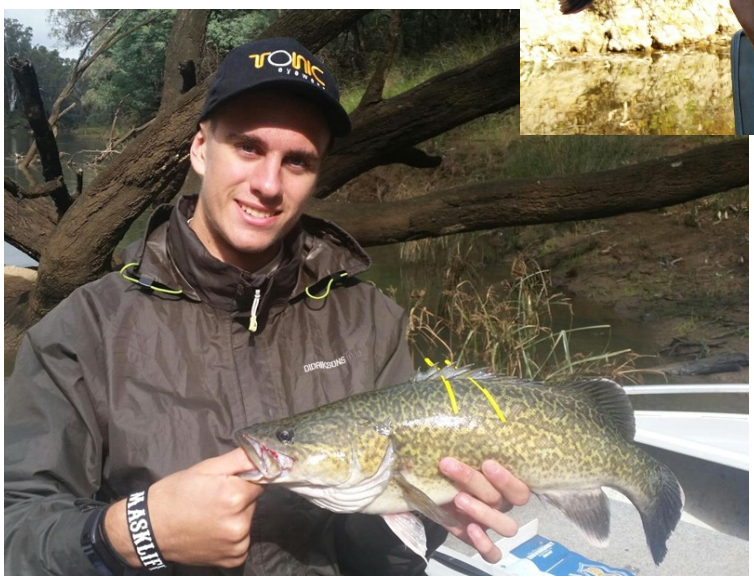
Cost benefit analysis

The cost of scientific angling events ranged from $8,991 to $18,708 (mean $11,961). Cost per participating angler ranged from $473 to $1,247 (mean $709) (14-21 anglers per event). In the current study, electrofishing was substantially more cost effective in capturing Murray cod, and caught a wider size range (Figure 10) than for angling. Cost per fish caught during scientific angling events ranged from $213 - $6,077 (mean $1,928), which was 1.4 to 20 times more expensive per fish than electrofishing (range $63-$2,500, mean $605) (Table 6).

Table 6. Cost per fish caught by angling during scientific angling events and caught by electrofishing.

River	Year	Cost per fish caught ($)		Cost per hour ($)		Catch per hour	
		Angling	Electro-fishing	Angling	Electro-fishing	Angling	Electro-fishing
Goulburn River	2015	1,829	128	75	2,500	0.04	19.5
	2016	789	144	40	2,451	0.05	21.3
	2017	562	75	47	2,577	0.08	34.3
Loddon River	2016	6,077	400	65	2,488	0.01	6.2
	2017	3,388	2,500	55	2,469	0.02	1.0
	2018	3,462	2,000	67	2,793	0.02	1.4
Ovens River	2015	1,247	63	101	2,469	0.08	39.3
	2016	213	65	44	2,457	0.21	37.6
	2017	268	69	39	2,611	.015	37.9
Range		**213-6,077**	**63-2,500**	**39-101**	**2,451-2,793**	**0.01-0.21**	**1.0-39.3**
Mean		**1,928**	**602**	**59**	**2,535**	**0.07**	**22.1**

Ray Miller with a 68.5 cm cod from the Ovens River in 2016 (photo Glen Scoble).



Bailey Thomas with a tagged 52 cm cod from the Goulburn River in 2017 (Photo: Paul Thomas).

Conclusions

This project and the FRDC project collected information from nine scientific angling events along with electro-fishing surveys following each event, conducted in three Victorian rivers, the Goulburn, Loddon and Ovens rivers, over three consecutive years between 2015 and 2018.

A total of 154 anglers participated in the project, representing 68 individuals (8 females and 60 males). Together anglers fished for a total of 1,861 hours, catching and tagging 143 Murray cod ranging in size from 20 to 100 cm. Most Murray cod were caught in the Ovens River (97), followed the Goulburn River (38), while just five fish were angled from the Loddon River. Angler catch rates ranged from 0-0.77 fish/ angler hr. Catch rates were usually, but not always, higher on the Saturday than the Sunday.

Electro-fishing surveys caught 790 Murray cod ranging in size from 4.5 to 124.5 cm, a significantly larger broad range than for fish caught by angling. Consistent with scientific angling, most fish were caught in the Ovens River, followed by the Goulburn River and then the Loddon River. Electrofishing catch rate ranged from 0-1.67 fish/ min. In comparison to historic electrofishing survey records, the abundance of Murray cod in the Ovens and Goulburn rivers has increased, but there has been little change in the Loddon River. Substantial stocking with hatchery-produced fingerlings does not appear to have enhanced the Murray cod fishery in the Loddon River.

The reasons why no Murray cod tagged by anglers were recaptured by anglers is not clear, though may be related the low number of fish tagged on the Saturday at any one site, and that fish caught, tagged and released by anglers on the Saturday may have learnt to avoid lures and been less catchable on the Sunday. Mortality following catch and release may also have been a factor. In contrast to angling, electrofishing recaptured 48 tagged Murray cod, seven of these were tagged by anglers.

Electrofishing tag-release-recapture data was used to estimate abundance of Murray cod in the Goulburn and Ovens rivers, which were 60.1 fish/ km (19.9 fish/ ha) and 85.3 fish/ km (33.0 fish/ ha), respectively. Insufficient Murray cod were tagged and recaptured to estimate abundance in the Loddon River.

Comparison of sizes of Murray cod caught by electrofishing in the Goulburn and Ovens rivers during this study and historic electrofishing records of these rivers (Goulburn River: 2006-2011. Ovens River: 2008-2011) was used to seek evidence of the potential effects of the recent change to the slot limit regulation on the size distribution of Murray cod and abundance of larger fish. However, results were unclear and contradictory, which suggest that it may be too soon to detect a meaningful change. Modelling suggested that a noticeable increase in the abundance of large fish may take five to 10 years. Changes may also be masked by an increasing trend towards catch and release by Murray cod anglers.

Anglers mainly fished with lures and to a lesser extent baits. Most Murray cod (51%) and golden perch (39%) were caught on spinnerbaits, followed by hard-bodied bib lures (Murray cod 24%, golden perch 36%). These results may reflect angler preference rather than the effectiveness of a particular type of lure in catching fish, although the preferential use of certain lures by anglers may also reflect their experiences regarding which lures are more effective.

Cost benefit analyses indicated that electrofishing was substantially more cost-effective in capturing Murray cod (range $63-$2,500, mean $605 per fish caught), and caught a wider size range, than for angling (range $213 - $6,077, mean $1,928 fish).

The project had strong support from, and engagement with, anglers in research supporting Murray cod fishery management. Although angling was not as cost effective at catching Murray cod as electrofishing, scientific angling events provided:

- complementary fishery information (angler catch rates, size of fish caught and length-dependent vulnerability estimates), which will assist fishery management.
- Broader social engagement with the recreational angling community through participation of anglers in events and social media outputs following events (by angers participating in events).

Recommendations

The project demonstrated that recreational anglers can undertake scientific activities, such as catch, measure, tag and release Murray cod, and provide information that will complement research programs supporting fisheries management objectives. Further involvement by anglers in supporting fisheries research and management may be achieved through participation in the VFAs Angler Diary Program (see https://vfa.vic.gov.au/science-in-fisheries/fisheries-research-findings/community-science/angler-diary-program) and using the *GoFishVic* App (https://itunes.apple.com/au/app/gofishvic/id1401118630?mt=8).

Utilising anglers to catch, measure, tag and release Murray cod may be considered an option to improve information gathering on specific fisheries. For example, as part of the VFAs "Million Murray Cod" Program (MMC), more than 1.15 million Murray cod fingerlings were stocked into Lake Eildon in the early 2010s (https://vfa.vic.gov.au/recreational-fishing/fish-stocking/murray-cod-million-lake-eildon). Recent social media posts indicate that Lake Eildon has become a recognised Murray cod fishery with good numbers of fish being caught and there is a change of catching fish over 1 m (Seeto 2016, Cooper 2017, Weda 2017, https://www.lakeeildon.com/fishing-reports/). The lake is also becoming known for its golden perch fishery (Vidler 2017, https://www.lakeeildon.com/fishing-reports/). Instigating an angler-based catch, tag and release program in Lake Eildon for Murray cod and golden perch will provide information on the growth, distribution and movement of these species in the lake, the size of the populations, social and economic value of the fisheries, as well as cost-effectively engaging anglers in fisheries research.

This project suggested it was too soon to detect a meaningful change in size structure of Murray cod and abundance of larger fish due to an introduction of new size limit regulations to the fishery. Further monitoring of the size structure of populations may be required within the next 5-10 years to detect a change.

Information collected from this project and the FRDC project will be combined with information from similar events undertaken in other states to better determine more robust estimates of the size and structure of Murray cod populations in Victoria and across the MDB.

Helen Wilson with a Loddon River golden perch caught in 2018 (Photo Anita Wilson).

Ray Miller with a 62.5 cm trout cod caught in the Ovens River in 2017, the largest caught during the project (Photo: Ben Evens).

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The project team acknowledges the traditional owners of the land on which the project was undertaken, Dja Dja Wurrang, Taungurung & Yorta Yorta, and their participation in scientific angling events.

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VrFish and assisted with angler participation at the Loddon River events while the Central Vic Lurer Casters assisted with angler participation at several events.

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Appendix I. Rivers and sites angled (An) and electro-fished (El) between 2015 and 2018

River		Site	Site Abbreviation	2015		2016		2017		2018	
				An	El	An	El	An	El	An	El
Goulburn River	*Upstream*	Campbells Bend (Murchison)	CAMP			X					
		Cemetery Bend - Maritz	CEME	X	X	X	X	X	X		
		Toolamba Boat Ramp A	TOOL-A	X		X		X			
		Toolamba Boat Ramp B	TOOL-B			X		X			
		Toolamba Boat Ramp C	TOOL-C	X	X		X		X		
		Bridge Rd Toolamba A	BRID-A	X	X	X	X	X	X		
		Bridge Rd Toolamba B	BRID-B	X	X	X	X	X	X		
		Pyke Road A	PYKE-A	X		X					
		Pyke Road B	PYKE-B	X	X	X	X	X	X		
		Shepparton Causeway A	SHEP-A			X		X			
		Shepparton Causeway B	SHEP-B	X	X		X	X	X		
	Downstream	Shepparton Causeway C	SHEP-C	X				X			
			TOTAL	**9**	**6**	**9**	**6**	**9**	**6**		
Loddon River	*Upstream*	Bridgewater 5	BRID5			X	X	X	X	X	X
		Bridgewater 4	BRID4							X	
		Bridgewater 3	BRID3			X					
		Bridgewater 2	BRID2			X	X	X	X		X
		Bridgewater 1	BRID1					X			
		Serpentine 1	SERP1			X		X		X	
		Serpentine 2	SERP2			X	X	X	X	X	X
		Serpentine 3	SERP3			X	X	X	X	X	X
		Fernihurst 2	FERN2			X	X	X	X	X	X
	Downstream	Fernihurst 1	FERN1			X	X	X	X	X	X
			TOTAL			**8**	**6**	**8**	**6**	**7**	**6**
Ovens River	*Upstream*	Tarrawingee	TARR	X	X		X	X	X		
		Wangaratta Wr (Apex Park)	WANG	X	X		X	X	X		
		Lavis' A	LAVI-A	X	X	X	X	X	X		
		Lavis' B	LAVI-B	X	X	X	X	X	X		
		Lavis' C	LAVI-C	X	X	X	X	X	X		
		Lavis' D	LAVI-D			X		X			
		Lavis' E	LAVI-E			X		X			
		Boorhamen Nth A	BOOR-A			X					
		Boorhamen Nth B	BOOR-B	X	X	X	X	X	X		
		Boorhamen Nth C	BOOR-C			X		X			
	Downstream	Parolas	PARO	X		X		X			
			TOTAL	**7**	**6**	**9**	**6**	**10**	**6**		

Appendix II. Guidelines for tagging Murray cod with streamer tags

Background

Fish tagging is an important tool used by researchers for fisheries management purposes. Tags are used to identify individuals and groups of individuals. Information from recaptured fish that have been tagged and released is used to understand fish stocks (size and distribution), fish growth, fish survival and fish movement.

As part of a large FRDC Murray cod fishery project, “Integrating fisher-derived and fishery-independent survey data to better understand and manage the Murray Cod fishery in the Murray-Darling Basin (2013/022)”, these is a need to catch, tag, release Murray cod, and then recapture them. Information from the recaptured fish will be used to estimate population size in study sites. Recreational anglers will be used to capture, tag and release Murray cod. Recapture of the tagged fish will occur the week after tagging.

These tagging guidelines are meant for use be experienced recreational anglers and Fisheries officers taking part in events, organised by Fisheries Victoria, at which anglers will capture Murray cod for the project.

What are streamer tags

Steamer tags (Hallprint Fish Tags, Adelaide, http://www.hallprint.com/) are a type of fish tag that is composed of a needle attached to a strip of polyethylene. Information, such as tag number, is written on the strip. Typically, the tag is inserted through the animal to be tagged, and then the needle is removed from the strip before the animal is released.

Streamer tags

Tagging angled fish

Equipment

1. Plastic box that will hold water and be large enough to hold Place the angled fish into a container of water. Water needs to be deep enough to fully cover the fish being held in the box. Regularly check that the temperature of the water in the fish box is not different from that of the river. Replace the water with freshwater from the river if is a noticeable difference can be felt by hand.
2. Environet® or equivalent soft-meshed landing net.
3. Pliers to aid in the removal of hooks and lures from fish.
4. Streamer tags and plastic container for disposal of needles.
5. Fish handling gloves or lip- grip pliers.
6. Fish measuring ruler or equivalent (e.g. brag mat).
7. Datasheet for recording information.

Handling fish safely and humanely

All steps should be taken to minimise stress and injury to fish that are caught. Anglers should abide by the National Code of Practice For Recreational & Sport Fishing (http://recfishingresearch.org/national-code-of-practice/), which

addresses four main areas of fishing responsibility; Treating fish humanely, looking after our fisheries, protecting the environment and respecting the rights of others.

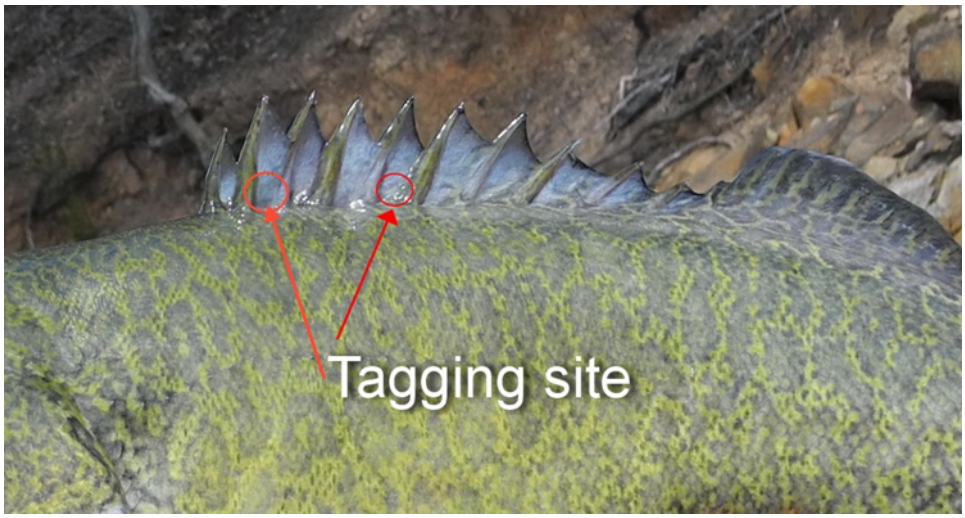
Tagging process

The tagging process requires a team of two anglers. When a Murray cod is captured, both anglers should participate in the tagging process to ensure the fish is released as quickly as possible. The process landing the fish to releasing the fish should take less than 2 minutes.

All anglers should use barbless hooks to facilitate speedy removal of bait hooks and lures and to minimise damage to the fish.

Small to medium fish (10 – 50 cm)

1. Initially, the angled fish should be held in the water in an Environet® or equivalent soft-meshed landing net by one angler while the other member of the team prepares the tagging equipment.
2. Use the landing to transfer the fish from the water to the fish box. If the fish is too large to be safely transferred to the fish box, or too large to comfortably fit into the fish box, follow instructions below for large fish. Do not tag fish < 10 cm in length.
3. Ensure there is enough water in the fish box to cover the fish and that the water temperature is not different from that of the river.
4. Remove fish hook or lure.
5. If the hook has been swallowed, cut the fishing line as close as possible to the mouth leaving the hook inside the fish.
6. Have ready one streamer tag and record the streamer tag number on the datasheet
7. Once the fish has settled down in the fish box,
    a. With one hand gently raise the spines of the dorsal fish to expose the webbing between the spines.
    b. With the other hand push the needle of the steamer tag through webbing between the spines of the dorsal fin, as close as possible to the base of the fin, immediately above the body of the fish.
    c. Tear off the needle and dispose of responsibly (sharps container).
    d. Ensure that the half of the steamer section of the tag is on each side of the fin, and that the narrow section of the tag is at the point where the tag passes through the fin.
    e. If there are concerns regarding the placement and security of the tag, insert a second streamer tag in the webbing between spines further along the dorsal fin.



Tagging sites: webbing between the spines of the dorsal fin, as close as possible to the base of the fin, immediately above the body of the fish

8. Measure the length of the fish on a ruler or equivalent (e.g. brag mat). The ruler should be cleaned and wet down before the fish is placed on to it. If possible, also take a photo of the fish.
9. Return the fish to the water with a soft-meshed landing net.
10. Complete all information on the datasheet for the fish capture.

Inserting the streamer tag needle through the webbing of the dorsal fin

Position of tag centrally after removal of the needle

Double-tagged fish

Large fish (> 50 cm)

This will require two people.

1. While one person holds the fish at the water surface beside the boat the second person undertakes the tagging process.
2. The fish may be held in place by using fish handling gloves to grasp the lower jaw of the fish.
3. If it is safe to do so, remove the hook or lure before tagging.
4. Have ready one streamer tag and record the streamer tag number on the datasheet.
5. Once the fish has settled down,
    a. With one hand gently raise the spines of the dorsal fish to expose the webbing between the spines
    b. With the other hand push the needle of the steamer tag through webbing of the fin, as close as possible to the base of the fin.
    c. Tear of the needle and dispose of responsibly (sharps container).
    d. Ensure that the half of the steamer section of the tag is on each side of the fin, and that the narrow section of the tag is at the point where the tag passes through the fin.
6. If possible, measure the length of the fish and take a photo of the fish before release.
7. Complete all information on the datasheet for the fish capture.

Appendix III. Volunteer attendance & safety forms

Department of Economic Development, Jobs, Transport & Resources — State Government Victoria

Job Safety Plan for Volunteer Activities

Activity: _Scientific Angling – Ovens River_____ Date: 25-26 / 3 / 2017

PART 1 INFORMATION TO BE COMPLETED BY PERSON PLANNING JOB

RESPONSIBLE OFFICER:	**CONTACT DETAILS:**
VOLUNTEER COORDINATOR(s)	**ACTIVITY START DATE:** 4 / 3. / 2017.... (No longer than 12 months) **ACTIVITY COMPLETION BY DATE:** ..5 / 3 / 2017
Job Number (office use only)	**OTHER RELEVANT INFORMATION**(e.g. contractors) Anglers are not part of a group so DEDJTR staff will act as volunteer coordinators. Names of angler volunteers and *emergency contacts are listed on ACTIVITY ATTENDANCE REGISTER FOR VOLUNTEERS*

LOCATION(s) (description and GPS or grid references): Various sites along the Ovens River, Victoria, from Everton downstream to confluence with Murray River.

Supporting document attached: ☐Maps

WORK TO BE DONE (description of job)

Angle and tag Murray cod as per prescribed scientific methodology

Supporting documents attached:
☐Traffic Management Plan ☐EMS ☐Detailed Job Plan ☐Pre work photos ☐Other_____

COMMUNICATIONS (Specify the required communication arrangements **OR** refer to communications plan)

Mobile phone: call in well-being checks throughout day. Phone/SMS designated Officer (Officer name & mobile phone number) when arrived at site, lunchtime (by designated time), and when on and off water.

Supporting documents attached: ☐Communications Plan

EMERGENCY RESPONSE PLAN (Specify the arrangements including First Aid **OR** refer to emergency plan)

Life threatening emergency, call 000.

Other : Notify designated Officer for assistance (Officer name & mobile phone number)

Closest Hospital: Emergency Department | Northeast Health Wangaratta– **(03) 5722 5261**

Other Hospitals: Yarrawonga Health — **03 5743 8111,** Corowa District Hospital — **(02) 6033 1333**

Supporting documents attached: ☐ site specific emergency response plan

IDENTIFYING INSTRUCTIONS AND COMPETENT PERSONS TO COMPLETE JOB OR PROJECT SAFELY

Question	YES	NO	Actions required
Does any component of the job involve risks that have not been covered in the SWP	☐	☒	**If yes,** develop a SWMS and attach. **If no,** proceed to next question.
Are suitable SWPs and SOIs available which cover all aspects of this job?	☒	☐	**If yes**, list the SWP and SOIs by name and reference number below. Proceed to next question **If no**, complete a SWMS and attach
Does the Volunteer Coordinator have an understanding and knowledge in the SWPs / SOIs and the relevant competencies/licences to perform the work as described in the SWP/SOIs ?	☒	☐	**If yes**, proceed to next step and list the resources required on the following page. **If no**, proceed to next question.
Will there be appropriate supervision present on the day?	☒	☐	**If yes**, proceed to next step and list the resources required on the following page. **If no**, stop and escalate to the RO's Manager.

Department of Economic Development, Jobs, Transport & Resources

Job Safety Plan for Volunteer Activities

Activity: _Scientific Angling – Ovens River_____ Date: 25-26 / 3 / 2017

IDENTIFY THE RELEVANT SAFE WORK PROCEDURES, SAFE OPERATING INSTRUCTIONS AND SAFE WORK METHOD STATEMENTS TO COMPLETE THE ACTIVITY.

Supporting documents attached:

☒ Safe Work Procedure ☒ Safe Operating Instructions ☒ Safe Work Method Statement

SWP, SOI or SWMS Name	Reference number
General Boating/Scientific Angling (SNOBS CREEK)	
Safe Operating Instructions-Trailer	SOI 064
Safe Operating Instructions- Boats Small Aluminium & Inflatable	SOI 061

RESOURCES REQUIRED	
PEOPLE	Up to 20 Volunteers in teams of two per boat Three (DEDJTR) staff
PLANT OR EQUIPMENT	Volunteers to use their own boats Volunteers use their own fishing gear
MATERIALS	Including provisions for water/refreshments, toilets, shade/weather protection. Water and snacks provided to volunteers Volunteers to provide own appropriate suns smart clothing and all weather protection (eg caps and rain wear)

ADDITIONAL COMMENTS / INSTRUCTIONS

Anglers use their own boats and the onus is the vessel having the correct safety equipment, is maintained in good order and complies with boating regulations/registrations. Operator to hold a current boat licence and operate vessel according to the conditions and potential hazards. Operate tagging and fish handling as per instructions and training.

Sign off by Responsible Officer _____ **Date:**...../...../.....

Department of Economic Development, Jobs, Transport & Resources — State Government Victoria

DAILY ACTIVITY REGISTER FOR VOLUNTEERS

Activity: ____**Ovens River** Murray cod fishing event_____ Date: **25-26 March 2017**

All persons participating in this activity must Txt to coordinator when on the water & again when off the water.

Date	*Team/ Volunteer Names*	*Boat Rego*	*Mobile phone*	*Check-out (on water) (TIME)*	*Check-in (off water) (TIME)*	*Comments*

Department of Economic Development, Jobs, Transport & Resources — State Government Victoria

ACTIVITY ATTENDANCE REGISTER FOR VOLUNTEERS

Activity: ____**Ovens River** Murray cod fishing event_____ Date: **25-26 March 2017**

All persons participating in this activity must sign in prior to commencing any tasks and sign out prior to leaving the activity site.

Declaration (please read)

By signing in to this activity I agree to the following requirements:

- *I understand the type of activity to be done and have read or been informed of the details in the Job Safety Plan for Volunteer Activities, Safe Work Procedures / Safe Operating Instructions/Safe Work Method Statement and Site Safety Survey for Volunteer Activities regarding any hazards and risk controls to be utilized.*
- *I will inform the Volunteer Coordinator (VC) or activity leader if I have any reason that may prevent or restrict me from undertaking any of the tasks I may be assigned.*
- *I have read and / or understood and agree to abide by the DEPIs Safety and Wellbeing Role Statement for Volunteers and will follow all lawful directions given to me by the VC and / or activity leader.*
- *I consent to photographs or videos taken on a project to be used by the Committee or the department for promotion purposes, or state my decision not to participate in photos or video production.*
- *I will not speak on behalf of the department.*

(Note: All persons under 16 must be signed in by a responsible person over the age of 18 who is present at the activity.)

Volunteer Name	*Signature to sign in*	*Arrival Time*	*Signature to sign Out*	*Departure time*	*Additional Emergency Contact Number*	*Comments (including any specialist task allocations)*

Murray cod Project Information

The data that you provide on this form will ultimately be used to investigate methods of assessing Murray cod populations at key Murray cod recreational fisheries across the Murray-Darling Basin.

Thank you for your contribution to fisheries research!

Contact Numbers:

Brett Ingram 0408 393 381

13Fish Report Illegal Activity

Supporters, collaborators & sponsors

Your fishing licence fees at work

TRELLY'S TACKLE WORLD

GV Codger

Arthur Rylah Institute for environmental research

Australian Government Fisheries Research & Development Corporation

Representing Victorian Recreational Fishers VR FISH

Department of Environment, Land, Water & Planning

State Government Victoria

Victorian Fisheries Authority

Murray cod Catch Card

Waterway **Loddon River - 2018**

Site No./name

Date

Team Name

Name **(A)**

Name **(B)**

TIME SPENT FISHING

When recording fishing times below, please consider breaks in excess of 10 minutes (e.g. meal breaks, or if you leave the designated zone) as a new session.

	Hot Zone	Grey Zone.	Start time	Finish time
(e.g.)	*Hot*		*07:30*	*12:30*
			:	:
			:	:
			:	:
			:	:
			:	:
			:	:
			:	:
Total Hours				

Appendix IV. Scientific angler catch card

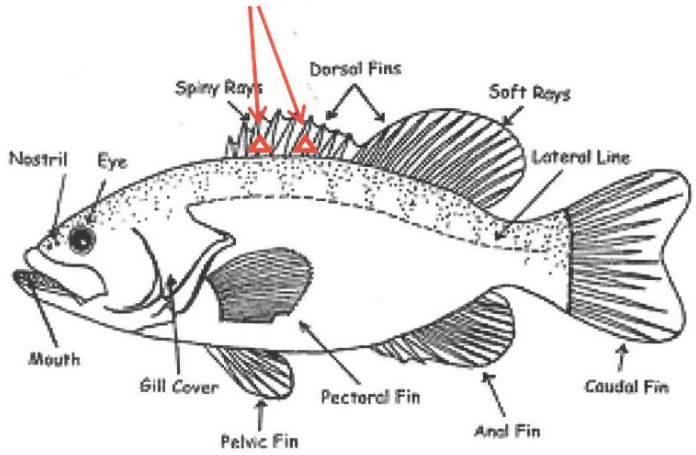
Tagging Procedure

When a fish is captured, bring it to the boat as quickly as possible and hold it in a fish friendly net or equivalent while the other member of the team prepares the sampling equipment. The following procedure should then be carried out as quickly as possible (approx. 5 mins):

- Bring the fish on board the canoe/boat or up onto the bank, apply lip-grip pliers and remove hooks,
- Transfer fish to brag mat and record its length (total length) on the data sheet opposite,
- If the fish has no ribbon tag, carefully insert **2 tags** in the soft-rayed dorsal fin (see picture below),
- Record the number of each new tag on sheet opposite or if tags already present, record numbers instead,
- Check all the relevant information has been recorded and release fish,

Record position where fish was captured on GPS or with pen on access/site map provided.

Streamer tag sites



Fisheries Victoria Research Permit Number: SP381.
DEDJTR AEC Approval Permit: DPIFish AEC Mar18 0101.

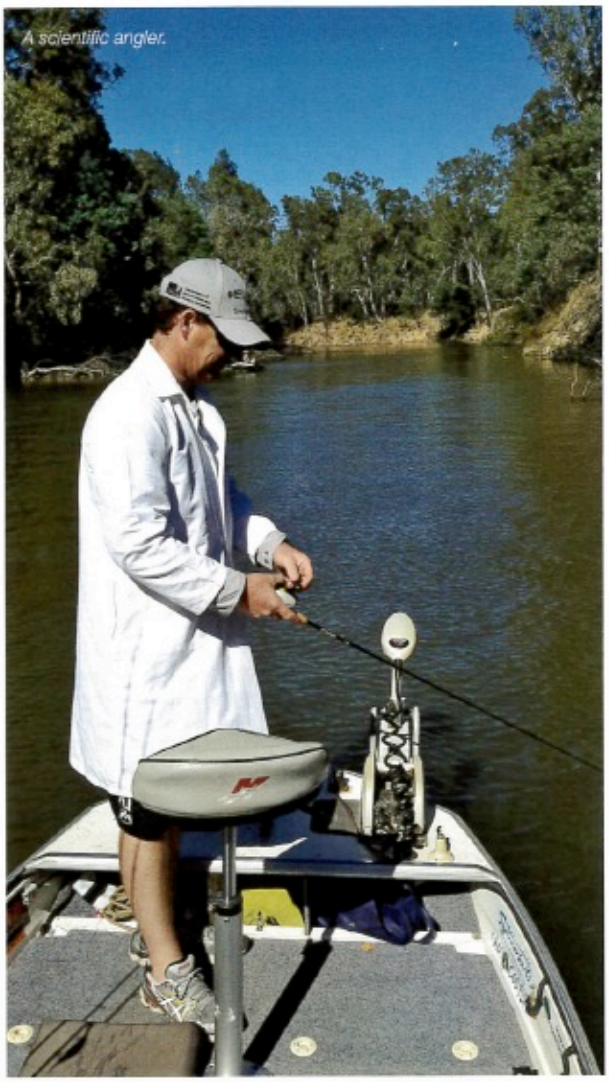
Fish No.	Species	Time	Angler (A or B)	Length (mm)	Streamer tag Numbers	Zone Hot or Grey	Bait Type: e.g. Lure, Fly, Spinnerbait, Soft Plastic, etc	Recapture No or Yes
(e.g.)	Cod	12:52	A	850	583 / 568	Hot	Lure	No
1					/			
2					/			
3					/			
4					/			
5					/			
6					/			
7					/			
8					/			
9					/			
10					/			
11					/			
12					/			

Appendix V. Reports on outcomes from scientific angling events conducted on the Goulburn, Ovens and Loddon rivers between 2015 and 2017

Scientific angling to support Murray cod research

– outcomes of events on Goulburn and Ovens Rivers 2015

BY DR BRETT INGRAM
Fisheries Victoria



A scientific angler.

During March 2015, Fisheries Victoria held two Murray cod fishing events at which anglers assisted in the capture and tagging of Murray cod to support a national, 3 year project "*Building a Stronger, more Resilient and Sustainable Murray cod Fishery*", which is funded by the Fisheries Research and Development Corporation and state fisheries agencies across the Murray-Darling Basin.

This is an innovative project that will allow researchers to better monitor Murray cod populations over time by using Murray cod catch information collected by both recreational anglers and electrofishing surveys.

This is an innovative project that will allow researchers to better monitor Murray cod populations over time by using Murray cod catch information collected by both recreational anglers and electrofishing surveys.

The two angling events occurred on the Goulburn and Ovens Rivers. Teams of anglers fished over two days at each event. These fishing events are part of a series of six fishing events held across the Murray - Darling Basin annually for the next three years. Murray cod that were caught were measured, tagged for identification purposes and released (left).

The project team from Fisheries Victoria kindly thank the overwhelming support of the 25 anglers that took part in the events.

A summary of the first year's results is provided below.

Event results

General observations

Anglers caught 25 Murray cod. A small number of golden perch and a trout cod were also caught by anglers. Most Murray cod were caught by spinnerbaits (13 fish), followed by bibbed (hard-bodied) lures (6 fish) and lipless crankbaits (4 fish), though these figures may reflect the popularity of these lures (or the angler's confidence in using the lures), rather than catching efficiency. Even though anglers caught more Murray cod on the Saturday than the Sunday, catch rate (hours/fish/team) was similar between the days. Most Murray cod were caught during the morning fishing session, which also corresponded with the highest number of teams fishing, with the peak in catch occurring between 9:00 and 10:00 am (Figure 2). On-going catch data, as recorded during these events, may provide further information on time of day when Murray cod are likely to be caught.

Electro-fishing caught more Murray cod, across a greater size range (237 fish, 4.5-88cm), than did angling (25 fish, 29.5-100 cm) (Table 1, Figure 1). This is not surprising considering that the latter used a method (mainly lure-fishing) that targeted larger fish, and relied on fish wanting to "take the bait". However, it is worth noting that angling caught more larger fish than did electro-fishing (Figure 1). For fish >40 cm, anglers caught 21 compared to 13 caught by electro-fishing.

Some Murray cod were observed but not captured by the electro-fishing crews, and of the Murray cod that were caught, generally only fish >10 cm were tagged. ARI has previous caught and tagged Murray cod in the Ovens River as part of another project. Some of these fish were caught during the present study, but were not considered as recaptured fish in the sampling period of this study.

Angled Murray cod with streamer tags inserted through dorsal fin.

Goulburn River event (14-15 March)

Nine teams (19 anglers) participated in the event. Over the two days of fishing 10 Murray cod (29.5 to 38 cm in length) were caught and tagged by seven anglers, 8 fish were caught on the Saturday.

Using information on the number of hours that anglers fish, there was a Murray cod caught every 2.4-9.6 hrs (mean 6.7hrs) by teams.

The electro-fishing survey conducted in the week after the event caught 78 Murray cod and tagged 31 of these. One Murray cod, caught by anglers at Toolamba Bridge B, was captured.

Ovens River event (28-29 March)

Seven teams (14 anglers) participated in the Ovens River event. Fifteen Murray cod (32 - 100 cm in length) were caught and tagged, 11 of these were caught on the Saturday. Half the anglers caught Murray cod. The largest Murray cod caught over both events were taken from the Ovens River at Lavis' A (95 cm) and Boorhamen Nth B (100 cm).

Using information on the number of hours that anglers fished, there was a Murray cod caught every 1.8-9.0 hrs (mean 5.6 hrs) by teams.

The electro-fishing survey caught 159 Murray cod and tagged 77. Just one of the Murray cod caught by anglers at Lavis' A was recaptured.

What's next

The Goulburn and Ovens River scientific angling events will be run again in 2016 and 2017 to build on the baseline data collected in 2015.

In addition, Fisheries Victoria has received funding from the Recreational Fishing Grants Program to extend the scientific angling program to the Loddon River. VRFish will by seeking up to 16 keen Murray cod fishers to take part in Loddon event.

Outcomes of the project

It is too early to draw any conclusions from the results of the initial events. However, when the project is completed, data collected from Victoria will be combined with data from similar events in other states for analysis. It is expected that this national project will build on our understanding of Murray cod populations and improve their monitoring and management. In particular the information gathered will help provide more robust estimates of population size and structure across larger areas, and help monitor outcomes of strategies to sustainably manage the fishery, such as changes to regulations (e.g. slot limits) and stock enhancement.

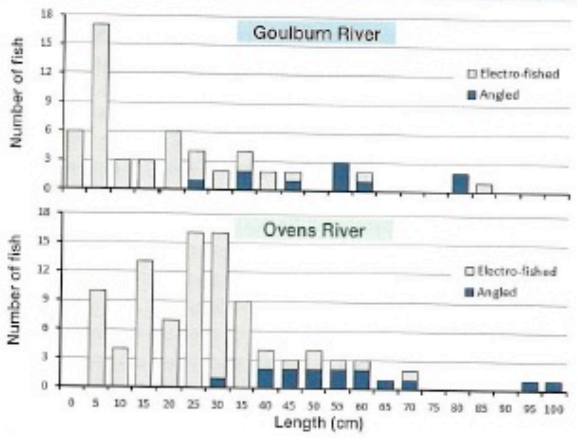


Figure 1. Length frequency distribution of Murray cod caught during angling and electro-fishing events in the Goulburn River and Ovens River.

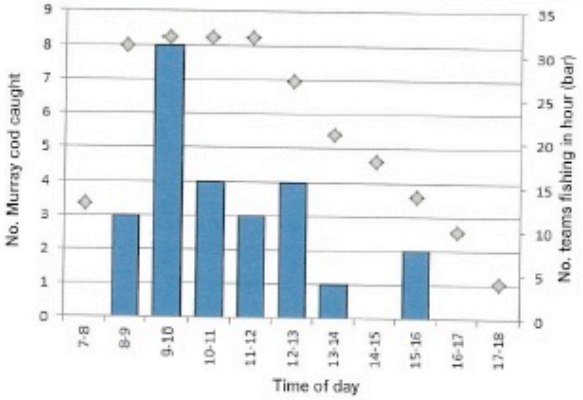
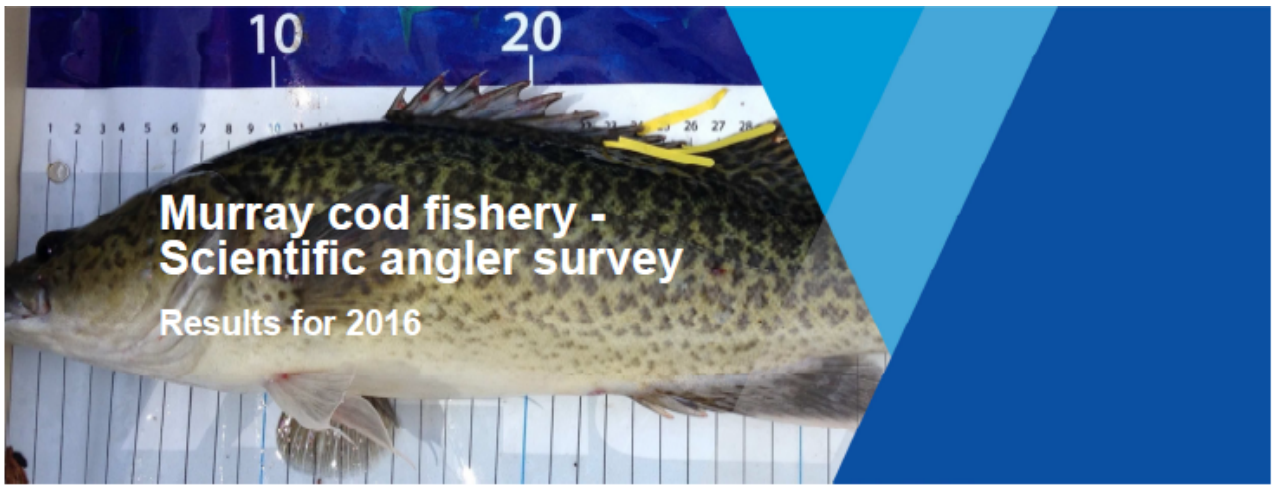


Figure 2. Number of Murray cod caught at different times of the day

Table 1. Summary of Murray cod caught, tagged and recaptured during angling events and subsequent electro-fishing surveys.

1 Excludes Murray cod that were observed but not caught.
2 Generally Murray cod < 10 cm were not tagged.
3 Values exclude recaptures of Murray cod that had been tagged prior to this project.

Event	Fishing method	Murray cod captured[1]	Murray cod tagged[2]	Recapture of angler-tagged fish	Recapture of electro-tagged fish[3]
Goulburn River	Angling	10	10	0	
	Electro-fishing	78	31	1	4
Ovens River	Angling	15	15	0	
	Electro-fishing	159	77	1	13
OVERALL	Angling	25	25	0	
	Electro-fishing	237	108	2	17



Murray cod fishery - Scientific angler survey

Results for 2016

Victorian recreational anglers are assisting in the capture and tagging of Murray cod to support research on Murray cod

Background

During the summer of 2016, three scientific angling events were conducted as part two linked projects,

Integrating fisher-derived and fishery-independent survey data to better understand and manage the Murray Cod fishery in the Murray-Darling Basin (FRDC Project 2013/022), which aims to improve knowledge and management of Murray cod fisheries in the Murray-Darling Basin (MDB). This project is funded by FRDC, the Victorian Government (DEDJTR and DELWP) and interstate fisheries agencies, and is supporting survey events in the Ovens and Goulburn Rivers, which commenced in 2015.

Implementing better practice Murray cod fishery management (RFL Large Grants Project LG33) is funded by the Victorian Government through the Recreational Fishing Licence (RFL) Trust Account and the Recreational Fishing Grants Program (RFGP). This project aims to extend baseline information on Victorian Murray cod fisheries to support the FRDC project and improve assessment of management changes. This project funds surveys in the Loddon River that commenced in 2016.

Importantly, both these projects are helping to engage anglers in research supporting Murray cod fishery management.

At each event, anglers intensively fish a designated 500 m stretch of river for at least 4 hours on Saturday and again on Sunday. All Murray cod caught are measured, tagged for identification purposes and released. In the week following the angling event, an electro-fishing team intensively surveys the same stretches of river, also measuring, tagging and releasing Murray cod.

Information collected from the angling events, along with results from electro-fishing surveys conducted after each event, will be combined with information from similar events in other states to better determine more robust estimates of the size and structure of Murray cod populations in Victoria and across the MDB.

Loddon River event (13-14 March 2016)

Eight teams of anglers intensively fished 1,000 m stretches of the Loddon River from above Bridgwater downstream to Serpentine. Thanks go to VRFish for assisting with organising teams for the event.

Even though the teams put in a lot of effort, just two Murray cod (43-57.8 cm) were caught and tagged.

The anglers, however, did quite well in catching 30 golden perch over the 2 days.

Electro-fishing surveys caught 25 Murray cod, one of which was a tagged fish.

Ovens River event (5-6 March 2016)

Over two days, six teams of anglers intensively fished 1,000 m stretchers of the Ovens River between Wangaratta and the Murray River.

Despite the hot weather anglers had a very productive weekend.

Twelve of the 17 anglers that fished over the weekend caught Murray cod, with 3 anglers

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each catching more than 5 fish. More Murray cod were caught on Saturday (32 Murray cod, effort 0.28 cod/hr) than Sunday (13 Murray cod, 0.13 cod/hr).

The largest and smallest Murray cod caught were 78 cm and 32 cm.

Twenty nine Murray cod were caught on spinnerbaits, 12 on bided lures, and 2 each on lipless crankbaits and surface lures.

Twenty two golden perch and one trout cod were also caught.

Subsequent electro-fishing surveys captured 153 Murray cod. Six tagged fish were recaptured, one of which had been tagged be anglers.

Goulburn River event (19-20 March 2016)

Over two days, 9 teams of anglers intensively fished 500 m stretches of the Goulburn River between Murchison and Shepparton.

A total of 29 fish were caught (12 Murray cod, 5 trout cod, 7 golden perch, 4 silver perch and 1 carp). Seven of the 18 anglers that fished over the weekend caught Murray cod. More Murray cod were caught this year than last year (see table below).

No tagged fish were recaptured.

Unlike all other events held to date, more Murray cod were caught on Sunday (7 Murray cod, effort 0.074 cod/hr) than Saturday (5 Murray cod, 0.035 cod/hr).

The largest and smallest Murray cod caught were 56 cm and 25 cm.

Five Murray cod were caught on bided lures, 4 on lipless crankbaits, 2 on spinnerbaits and 1 on bait.

Some anglers commented on how much rubbish was in the river especially near Shepparton, which was disappointing to hear. But on the up side, a few lures were recycled from the rubbish.

It was a pleasant surprise to see 5 trout cod caught (14-30 cm). These fish may be from natural spawnings as the last time the Goulburn River below Nagambie was stocked with trout cod was in 1996/97 (although, in January 2014, 15,000 fingerlings were released between Molesworth and Trawool).

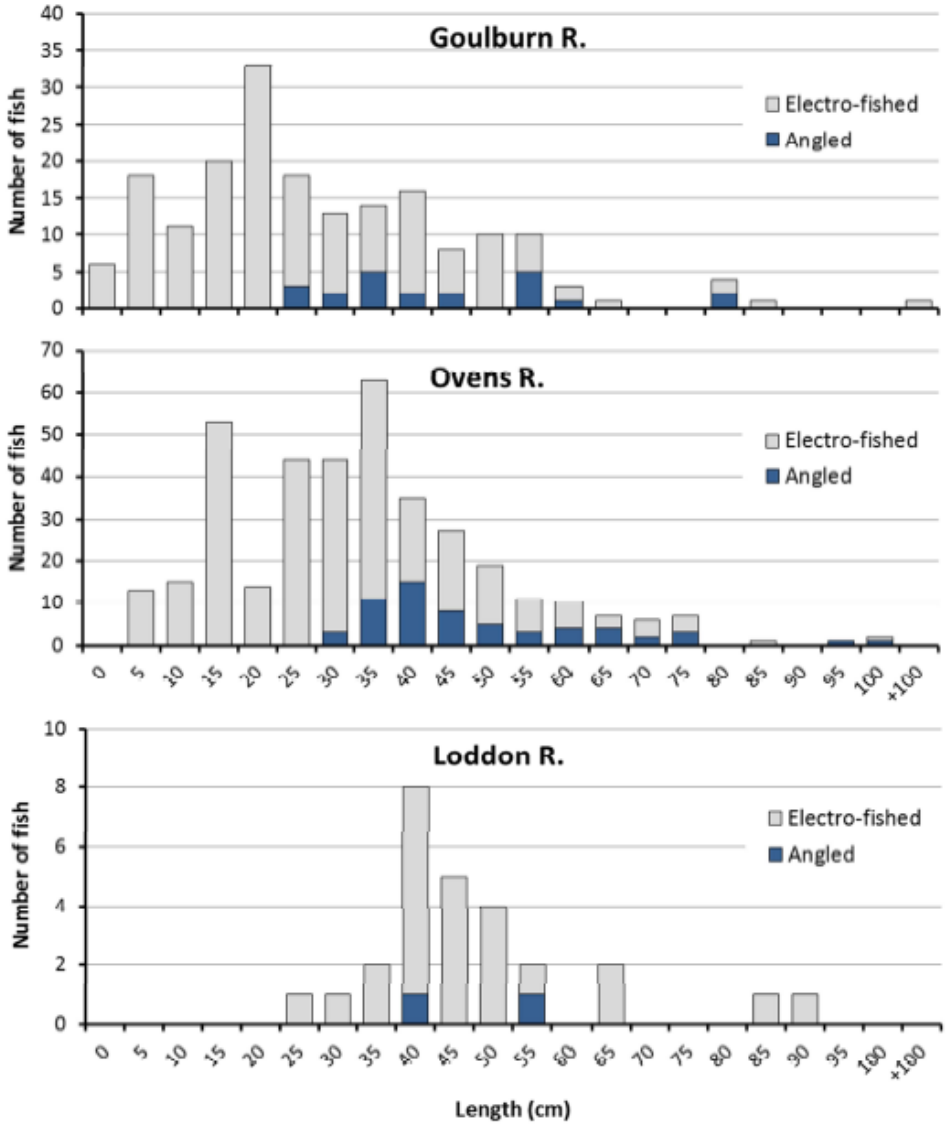
The electro-fishing surveys caught 87 Murray cod, and 3 of the 7 fish recaptured had been tagged by anglers.

Prepared by

Brett Ingram[1] and Scott Raymond[2]

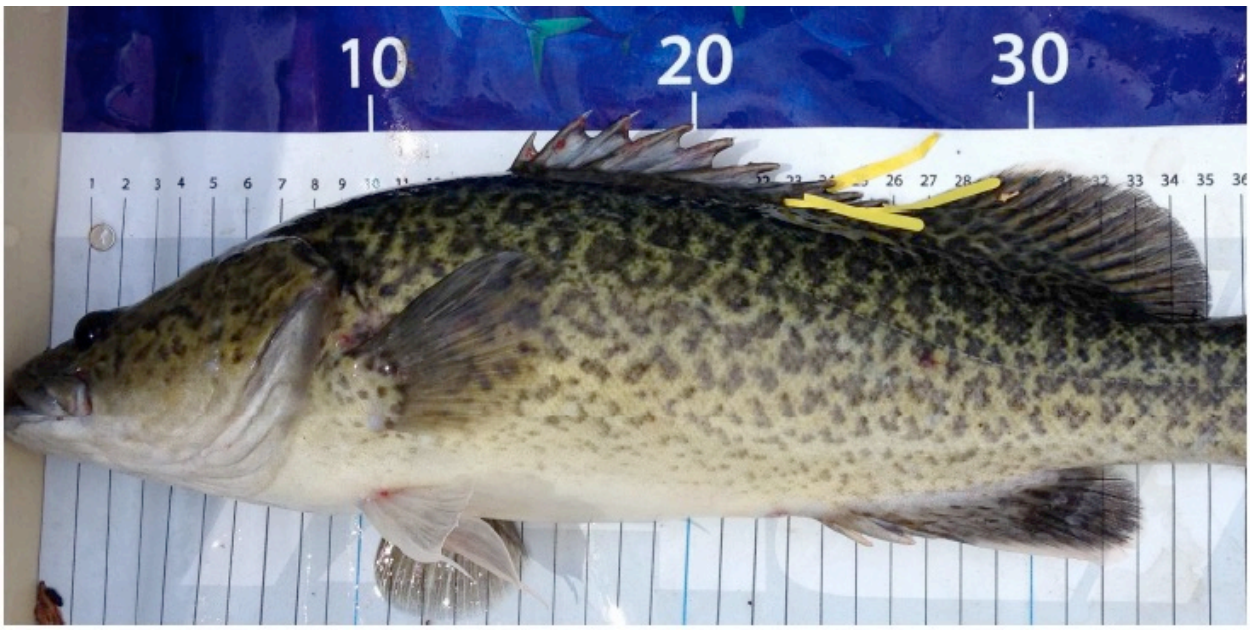
1. Fisheries Victoria, DEDJTR, Private Bag 20, Alexandra, 3714
2. ARI, DELWP, Brown Street, Heidelberg

Murray cod Length-frequency distribution data



Summary of scientific angling and electro-fishing surveys – all events

Event	Scientific angling					Electro-fishing survey				
	No. anglers	No. Murray cod caught and tagged	No. cod recaptured by anglers	Size range (mean) (cm)	Mean Fishing effort (cod/hr)	No. Murray cod caught	No. cod recaptured by electro-fishing			Size range (mean) (cm)
							Tagged by anglers	Tagged by electro-fishers	Total	
Goulburn R. (2015)	20	10	0	29.5-83 (54.8)	0.04	78	1	4	5	4.5-88(26.7)
Goulburn R. (2016)	18	12	0	25-56 (39)	0.05	87	3	4	7	7.6-115.5 (30.1)
Ovens R. (2015)	15	15	0	32-100 (59.7)	0.07	159	1	13	14	6.8-101(33.1)
Ovens R. (2016)	17	45	0	32-78 (47.5)	0.21	153	1	5	6	6.7-88.7 (33.1)
Loddon R. (2016)	16	2	0	43-57.8 (50.4)	0.01	25		2	2	29.8-91 (50.2)
Overall	**86**	**84**	**0**	**29-100 (49.4)**	**0.08**	**502**	**6**	**28**	**34**	**4.5-115.5 (32.4)**



Murray cod fishery - Scientific angler surveys

Results for 2017 events

Ross Winstanley with a tagged 47 cm Murray cod caught on a spinnerbait from the Goulburn River (2015) (Photo: Marc Ainsworth).

VICTORIAN RECREATIONAL ANGLERS ARE ASSISTING IN THE CAPTURE AND TAGGING OF MURRAY COD TO SUPPORT RESEARCH AND FISHERY MANAGMENT

BACKGROUND

During the summer of 2017, three scientific angling events were conducted as part of two linked projects,

Integrating fisher-derived and fishery-independent survey data to better understand and manage the Murray Cod fishery in the Murray-Darling Basin (FRDC Project 2013/022). This project aims to improve knowledge and management of Murray cod fisheries in the Murray-Darling Basin (MDB). The project is funded by FRDC, the Victorian Government (DEDJTR and DELWP) and interstate fisheries agencies, and is supporting survey events in the Ovens and Goulburn Rivers, which commenced in 2015.

Implementing better practice Murray cod fishery management (RFL Large Grants Project LG33) is funded by the Victorian Government through the Recreational Fishing Licence (RFL) Trust Account and the Recreational Fishing Grants Program (RFGP). This project aims to extend baseline information on Victorian Murray cod fisheries to support the FRDC project and improve assessment of management changes. This project funds surveys in the Loddon River that commenced in 2016.

Importantly, both these projects are helping to engage anglers in research supporting Murray cod fishery management.

At each event, anglers intensively fish a designated 1,000 m stretch of river for at least 4 hours on Saturday and again on Sunday. All Murray cod caught are measured, tagged for identification purposes and released. In the week following the angling event, an electro-fishing team intensively surveys the same stretches of river, also measuring, tagging and releasing Murray cod.

Information collected from the angling events, along with results from electro-fishing surveys conducted after each event, will be combined with information from similar events being undertaken in other states to better determine more robust estimates of the size and structure of Murray cod populations in Victoria and across the MDB.

RESULTS FOR 2017 EVENTS

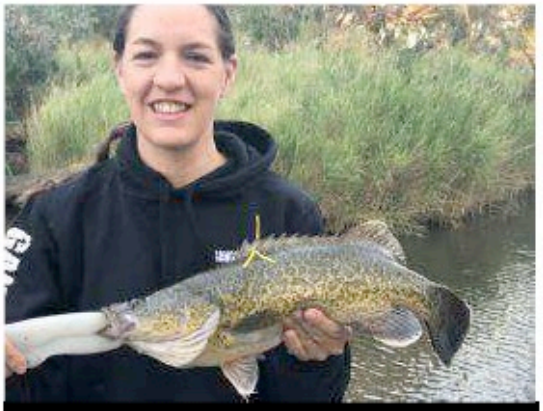
Loddon River (4-5 March 2017)

Eight teams of anglers fished 1,000 m stretches of the Loddon River from above Bridgwater downstream to Fernihurst. Thanks go to VRFish for assisting with organising teams for the event.

Three Murray cod were caught and tagged (43.5-59 cm), which was one more than last year. Four golden perch were also caught, which was considerably lower

than last year when 30 fish were caught in 2016. All fish were caught at the downstream sites (Serpentine and Fernihurst). The water at sites upstream of Bridgewater was very turbid, which may have affected angling.

Electro-fishing surveys caught four fish only, which was considerably less than the previous year when 25 were caught. No tagged fish were recaptured.



Karen Rees caught this 53.5 cm fish on a surface lure in the Loddon River near Serpentine (Photo: Justin Rees).

Ovens River (25-26 March 2017)

Over two days, 10 teams of anglers fished 1,000 m stretchers of the Ovens River between Tarrawingee and the Murray River.

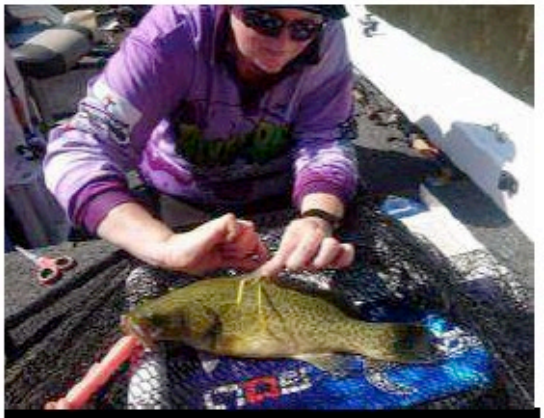
Despite the rain, teams had a very productive weekend with 15 anglers catching 37 Murray cod measuring 20 – 76 cm. Two anglers each caught six fish each. Eighteen Murray cod were caught on spinnerbaits, eight on bib lures and six on surface lures.

Three golden perch and a 62.5 cm trout cod, that took a surface lure, were also caught over the weekend.

Steve "Trelly" Threlfall with a 37 cm Murray cod caught in the Ovens River downstream of Wangaratta (photo: Owen Gregory)

Despite a large number of Murray cod being tagged by anglers, none were recaptured on the second day of fishing.

Subsequent electro-fishing surveys captured 167 Murray cod, which was more than last year when 153 were caught. Eleven tagged fish were recaptured, one of which had been tagged be anglers.



Deanne Brassil tagging a 44 cm fish caught in the Ovens River (Photo: Anita Wilson)

Paul Thomas with a tagged Ovens River Murray cod caught on a spinnerbait (Photo: Bailey Thomas)

Goulburn River (22-23 April 2017)

Over two days, nine teams of anglers fished 1,000 m stretches of the Goulburn River between Murchison and Shepparton.

Sixteen Murray cod measuring 28 – 63 cm were caught and tagged by nine anglers. This is an improvement on last year when 12 Murray cod were caught. Murray cod were caught mainly on spinnerbaits (6 fish) and bait (6 fish). Twelve trout cod, three golden perch and a silver perch were also caught over the weekend.

No tagged Murray cod were recaptured by anglers.

The electro-fishing surveys caught 134 Murray cod, included the largest fish (124.5 cm) caught over all events. Electro-fished Murray cod were 5.4 – 124.5 cm in length. Three tagged fish were recaptured.

Dion Hayes with 51 cm Murray cod caught on a surface lure in the Goulburn River upstream of Shepparton (Photo: Paul Taylor).

OVERALL OF RESULTS – ALL RIVERS AND ALL EVENTS (2015 - 2017)

To date eight events have been conducted, three each on the Goulburn and Oven rivers and 2 on the Loddon River. A total of 55 anglers fished for 1,520 hours in the events, and 35 caught and tagged 140 Murray cod. Anglers also caught 76 golden perch (Goulburn, Loddon and Ovens rivers), 19 trout cod (Goulburn and Ovens rivers), five silver perch (Goulburn River), one redfin perch (Loddon River) and one carp (Goulburn River).

Most Murray cod were caught in the Ovens River (97 fish), followed the Goulburn River (38 fish), while just five fish were angled from the Loddon River. Average angler catch rates were,

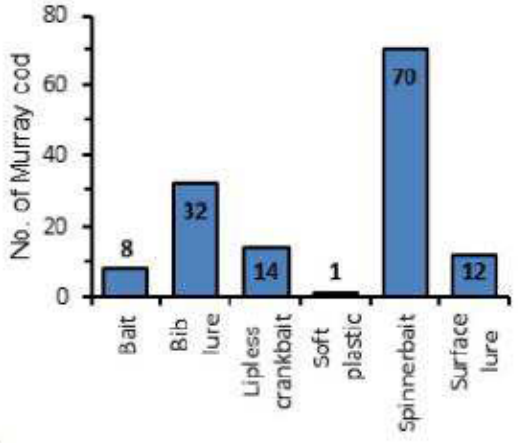
- Ovens River - 6.8 hours per cod
- Goulburn River 17.5 hours per cod
- Loddon River 81.4 hours per cod.

Murray cod caught by anglers ranged in size from 20 - 100 cm in length, with both the smallest and largest fish being caught in the Ovens River.

Most Murray cod were caught using spinnerbaits (51%) followed by bib lures (23%) and lipless crankbaits (10%). However, these results may reflect angler preferences rather than lure effectiveness in catching fish.

Electro-fishing surveys caught 807 Murray cod ranging in size from 4.5 - 124.5 cm. Of these 266 were tagged on the first day of surveys at each event. Electro-fishing caught a broader size range of fish compared to angling, which is a reflection of the selectivity of gear used. Anglers fished mainly with lurers that targeted larger fish.

Although anglers did not recapture any tagged Murray cod, electro-fishing surveys recaptured 48 tagged fish, seven of which had been tagged by anglers.



Number of Murray cod caught on different lure types and bait.

Electro-fishing boat in the Loddon River.

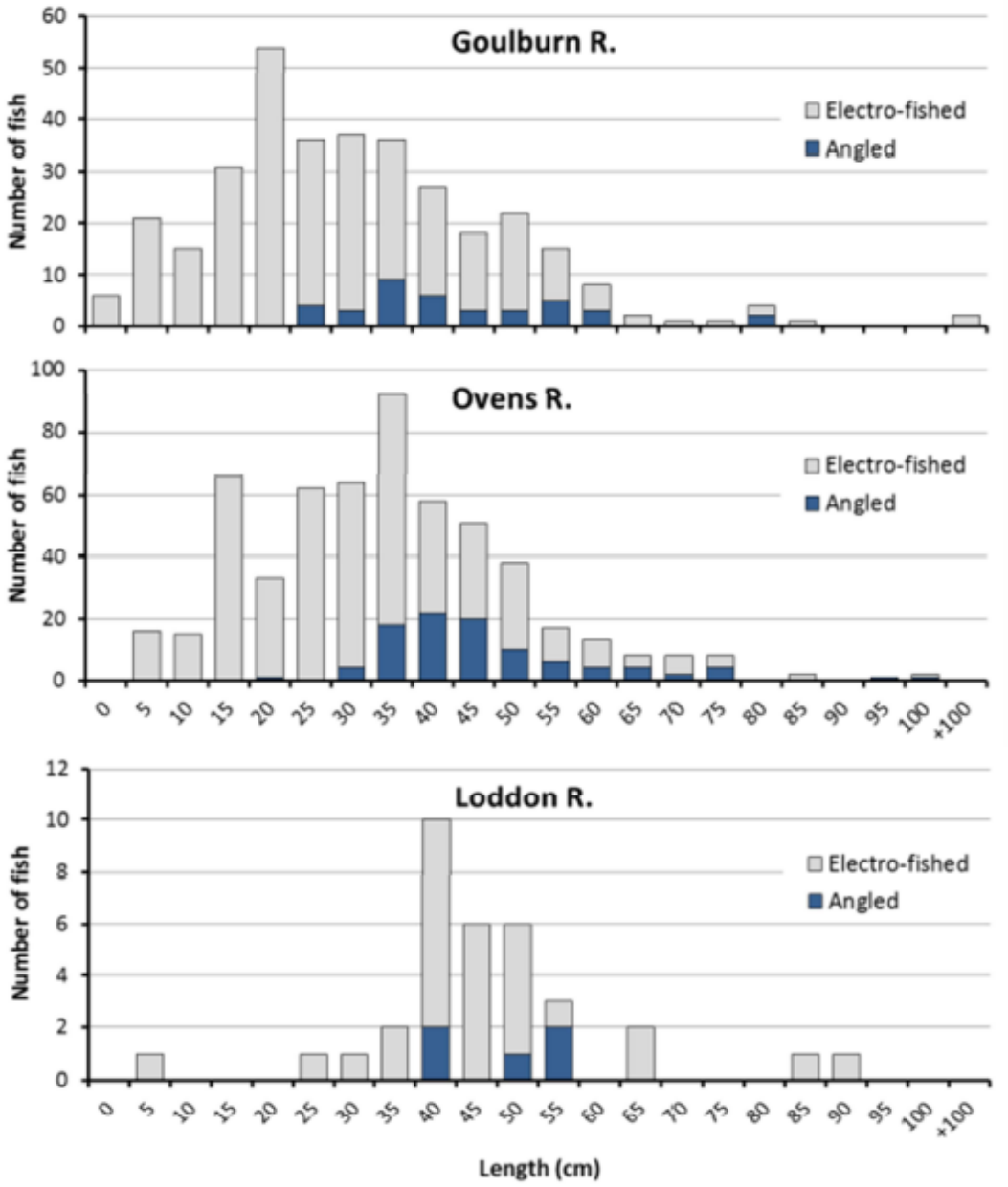
Prepared by

Brett Ingram[1] and Scott Raymond[2]

1. Victorian Fisheries Authority, Private Bag 20, Alexandra, 3714.
2. Arthur Rylah Institute, DELWP, Brown Street, Heidelberg.

Date: 20 July 2017.

Murray cod Length-frequency distribution data (all events, 2015 - 2017)



Summary of scientific angling and electro-fishing surveys – all events (2015 - 2017)

Event	Scientific angling					Electro-fishing survey				
	No. anglers	No. cod caught and tagged	No. cod recaptured by anglers	Size range (mean) (cm)	Mean Fishing effort (cod/hr)	No. Murray cod caught	No. cod recaptured by electro-fishing			Size range (mean) (cm)
							Tagged by anglers	Tagged by electro-fishers	Total	
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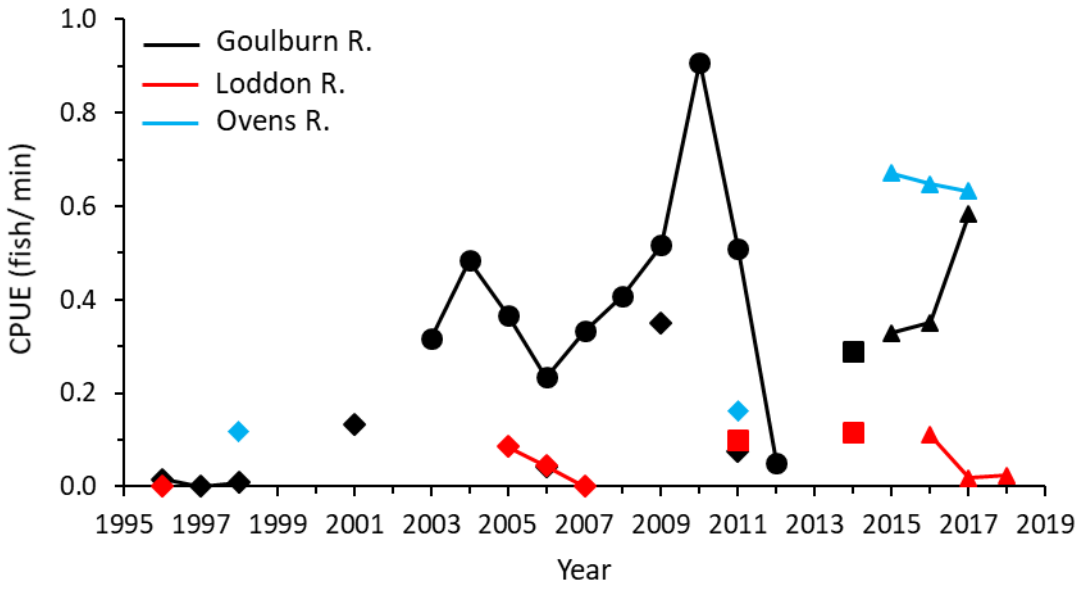
Goulburn R. (2016)	18	12	0	25-56 (39)	0.05	87	3	4	7	7.6-115.5 (30.1)
Goulburn R. (2017)	19	16	0	28-63 (43.3)	0.09	134	0	3	3	5.4-124.5 (34.5)
Ovens R. (2015)	15	15	0	32-100 (59.7)	0.07	159	1	13	14	6.8-101 (33.1)
Ovens R. (2016)	17	45	0	32-78 (47.5)	0.21	153	1	5	6	6.7-88.7 (33.1)
Ovens R. (2017)	19	37	0	20-76 (45.2)	0.15	167	1	10	11	6.5-85 (35.9)
Loddon R. (2016)	16	2	0	43-57.8 (50.4)	0.01	25	0	2	2	29.8-91 (50.2)
Loddon R. (2017)	15	3	0	43.5-59 (52)	0.01	4	0	0	0	8.4-50 (37.5)
Overall	**139**	**140**	**0**	**20-100 (47.6)**	**0.08**	**807**	**7**	**41**	**48**	**4.5-124.5 (33.4)**

Appendix VI. Historic electrofishing CPUE for the Goulburn, Loddon and Ovens rivers



Data sources: Δ Current study.

◊ Victorian Fisheries Authority fishery survey database (1996-2011).

□ Ingram, B.A., Hunt, T.L., Lieschke, J. and Douglas, J. (2015). Monitoring fish stockings in Victoria: 2014 native fish surveys. Recreation Fishing Grants Program Research Report. Department of Economic Development, Jobs, Transport and Resources, Queenscliff. 50 pp.

○ Koster, W., Crook, D., Dawson, D. and Moloney, P. (2012). Status of fish populations in the lower Goulburn River (2003-2012). Arthur Rylah Institute for Environmental Research Unpublished Client Report for Goulburn Broken Catchment Management Authority, Department of Sustainability and Environment, Heidelberg, Victoria.

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